NEW MATRICULATION
ZOOLOGY

8

NEW MATRICULATION ZOOLOGY 8

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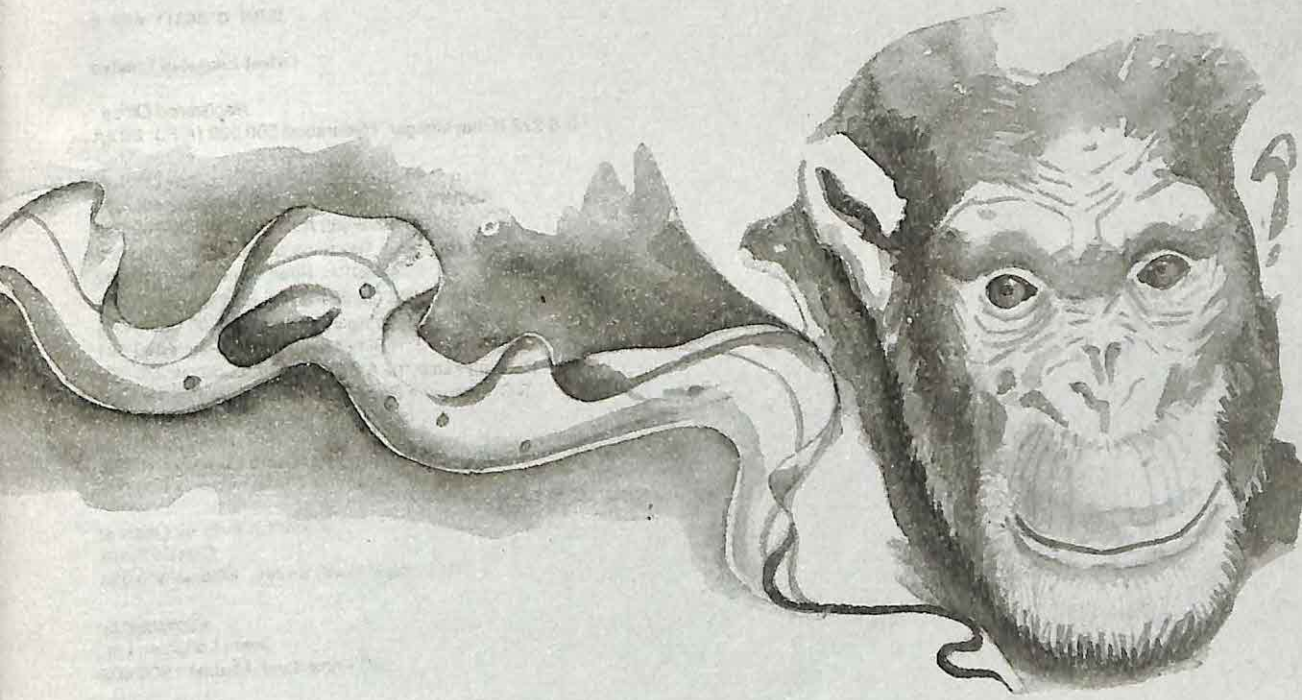

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To the teacher

New Matriculation Zoology is a series of five books developed for class 6-10 of the Tamil Nadu Matriculation system. It closely follows the new enriched Matriculation syllabus.

One of the main features of the new syllabus is that activity and observation are given a very important place in understanding science. Every effort has been made to unfold the scope and purpose of the syllabus. This series departs from the conventional and emphasises a practical, 'discovery' and 'learning by doing' approach.

The subject matter to be studied has been carefully arranged keeping in mind the age level and psychology of the child. No effort has been spared to support the text with clear, labelled illustrations. The language has been kept simple and direct to enable the students to read the text themselves.

Several activities and projects have been suggested, wherever possible, within the scope of the lesson. Most of these need simple improvising or inexpensive materials.

The exercises for each chapter are exhaustive and include questions based on comprehension and application of basic principles rather than on mere recall.

It has been the concern of the authors that children are encouraged to discover for themselves the pleasure of learning about the fascinating 'animals'.

The author

S. No.	Concept/theme	Expected learning outcome	Teaching / learning activities
	inner dermis-accessory structure (nail, hair, glands, touch corpuscles). Functions-shape, protection against mechanical injury, prevention of escape of body fluids, sensory, maintenance of body temperature, excretion, manufacture of vitamin D, filtering of air by means of hair in nose, ear, eyelashes, protection of inner organs from ultraviolet rays.		
2.4	Muscle-types - outline of structure and functions of muscles. Voluntary muscles-muscles of the arm and legs; involuntary-cardiac; sphincter muscles, cardiac muscular contraction, importance of actin and myosin.	Sees relationship between the structure and functions of types of muscles.	Prepares posters on various muscles.
2.5	Animal growth - variation of growth in the body - external or internal factors for growth.	Analyses growth of animal under various experimental conditions.	
3.	**Nutrition and hygiene**		
3.1	Menace of adulteration of food and medicines.	Realises the evil of adulteration of food and medicines.	Collects paper cuttings, reporting cases of adulterations of food and medicines.
4.	**Reproduction-Inheritance and Evolution.**		
4.1	Alternation of generation - Hydra - sexual forms.	Realises the occurance of alternation of generation in some animals.	
4.2	Early development in frog, metamorphosis (butterfly and frog) fertilisation-zygote-cleavage-blastula-gastrula - tail bud stage (only brief account required)	Recognises metamorphosis of butterfly and frog.	Collects the stages in the life cycle of Butterfly and Frog from nature.
4.3	Reproduction in animals. Union of male and female gametes (in fish, frog, birds and mammals: breeding season)	Recalls the importance of sexual reproduction in animals.	Observes reproduction in animals (frog and fowl).
4.4	Other methods-gemmules (sponges)-Regeneration in Amoeba, Hydra, Planaria, Earthworm, Starfish, Fishes, Lizard and Man (Wound healing)	Wonders at the various methods of reproduction adopted by animals in nature, including regeneration.	Observes the methods of reproduction in Earthworm and Fishes.

MATRICULATION SYLLABUS FOR STANDARD VIII – ZOOLOGY

S. No.	*Concept/theme*	*Expected learning outcome*	*Teaching / learning activities*
1.	**Diversity of living organisms**		
1.1	Outline classification of animals.	Recalls the outline classification of animals. Nomenclature-vernacular or common names-scientific names - binomial nomenclature; species, genus, families, orders, classes, phyla, divisions, kingdoms-systems of classification and their significance.	Collects the pictures of few animals and taxonomists and pastes them in an album.
1.2	Utility of classification of animals. Units of classification from larger to smaller.	Sees relationships among different groups of organisms. Arranges things in specific order, plan or scheme - gives suitable examples.	A few insects, worm etc., are supplied and the students are asked to classify them. Group work and discussion.
1.3	Major animal groups with salient characteristics with Indian examples.	Recalls classification of the animal kingdom.	Prepares a tree of classification. Protozoa versus Metazoa — skit.
2	**Organisation of animals**		
2.1	Types of animal tissues.	Recalls the fundamental animal tissues.	Microscopic examination of various animal tissues and recording of the structure of each.
2.2	Types of animal tissues and their functions in detail. Epithelial, vascular, muscular, nervous and supporting tissue (cartilage and bone) (epithelial, muscular, connective, nervous); the compound tissue; structures such as skin, walls of stomach, intestine, retina, etc. Recognises the epithelial, squamous, cuboidal, columnar, ciliated, sensory, glandular and germinal tissues; vascular tissue — blood plasma and its composition; Muscular — various types; Nervous — unipolar, bipolar, and multipolar neurons; Bone tissue-osteoblasts, marrow cavity. Haverisan system lucanae etc. Realises that the classification of tissues is based on structure & functions.	Recalls various types of animal tissues. Recognises some of the related animal tissues.	
2.3	Skin — outline of structure and functions of skin. Skin or integument, outer epidermis,	Sees relationship between the structure and functions of skin.	Observation of model of skin - identification of various parts.

S. No.	Concept/theme	Expected learning outcome	Teaching / learning activities
4.5	Perpetuation of the human species-population explosion - importance of population education.	Develops awareness towards population control.	Celebrating population education week in the school and involving children in a variety of activities.
4.6	Parental care-meaning and need-examples of parental care.	Recognises parental care in animals.	Visits a zoo to observe parental care in different animals and makes a record of the observations.

PRACTICALS

1. Microslides a. Hydra b. Amoeba c. Epithelial tissue
2. Developmental stages a. Frog b. Butterfly
3. Identification of the following preserved specimens:
   a. Earthworm b. Starfish c. Frog d. Pigeon e. Rat

Contents

1. Diversity of living organisms

Outline classification of animals - nomenclature - vernacular - scientific names - binomial nomenclature - systems of classification - significance - utility of classification - units of classification - major animal groups with salient characteristics - Indian examples.

Organisms, small and large, show many variations in their structure and mode of life. Though some plants and animals have an acellular organisation, many of them have a cellular organisation. These many-celled organisms are not only numerous, but also varied with different patterns of organisation. Some are simple whereas others are complex.

1.1 Outline classification of animals

Taxonomy or classification is one branch in zoology that deals with identification, nomenclature and classification of animals. Taxonomy was initiated by the Greek philosophers *Plato* and *Aristotle* and developed as a branch of science by *Theophrastus*. The chief aim of taxonomy is to acquire knowledge of different animals, their respective names, similarities and differences, inter-relationships, their world-wide distribution, etc. It also helps us to know how evolution has taken place among the animal population.

NOMENCLATURE AND ITS SIGNIFICANCE

Names are required to recognise different types of organisms. The system of providing organisms with suitable and distinct names is called *nomenclature*.

VERNACULAR OR COMMON NAMES

The vernacular or common names are names given to organisms by the residents of a particular region. These people are familiar with the organisms since their childhood and hence name them in their local language. Nevertheless, these names cannot be adopted by the biologists due to the following reasons:

1. Living things are spread over the world and not confined to a particular region.
2. Some common names have no significance and are in fact misleading.
3. A single organism may be given several names in the same language.
4. A single name can refer to two different animals.

5. Common names are not convenient to use when scientists of different regions of the world communicate with each other.

BINOMIAL NOMECLATURE (LINNAEAN CLASSIFICATION)

Fig. 1.1 Linnaeus

Carl von Linnaeus put forward the binomial (from the Latin *bis:* twice, and *nomen:* name) system of nomenclature. In this system every organism is given a name that consists of two words. The first word of this scientific name is the *genus* or *generic name* which is like a proper noun and its first letter is a capital letter. The second word of the name is the *species* or *specific name*. This is like an adjective and its initial letter is written as a small (not capital) letter. Scientific names are printed in italics, e.g., *Panthera tigris* (tiger) *Felis domestica* (cat). These names are either derived from Latin or are Latinized because of the fact that this language is dead and, therefore, cannot be changed in form or spelling with time, as could probably be done with other languages. Sometimes the name of the scientist who named the organism is also appended to the two-word name in an abbreviated form.

FEATURES OF BINOMIALS

1. Every organism known to science is given a single and specific name.
2. The name clearly identifies the organism. The local, common or vernacular names have application restricted to only a particular area and further, their meanings vary from region to region or even from person to person. This results in confusion and the understanding of the species becomes negligible.
3. The names are based on some of the characteristics of the organism, region or the scientist's name.
4. The names indicate relationships among the different species of a genus.
5. A wrong binomial name can be easily corrected. This is almost impossible to do in the case of a common name.

1.2 Utility of classification of animals and units of classification

UNITS OF CLASSIFICATION

In simple terms 'species' refers to different kinds of organisms. A 'species' is a kind of animal that is distinctly different from other kinds in certain essential characteristics. Expanded further, a species is a group of individuals having a certian number of characteristics and morphological similarities among themselves. They perpetuate themselves generation after generation. This group of individuals remain isolated from other groups of individuals, and has its own morphological characteristics and similarities. They don't usually interbreed with the other groups, e.g., *Felis domestica* (the cat); *Periplaneta americana* (a species of cockroach). This particular phenomenon enables them to maintain their respective characteristics generation after generation.

The word '*genus*' represents another taxonomic hierarchical unit. Its rank always next in

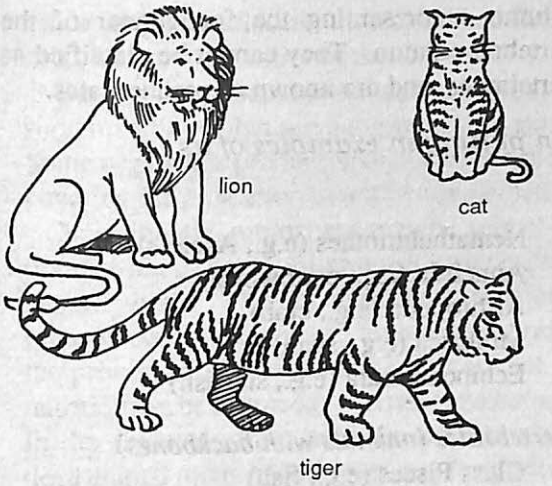


Fig. 1.2 The lion, the tiger and the cat make three species of a single genus (Felis).

importance to that of the species. Each genus is nothing but a group, of a few or more species which are morphologically related to each other. The generic name *'Felis'* is given to a particular group — of all types of cats — e.g., domestic cat, panther, lion, etc.

The *family* occupies a rank higher than that of the genus in a taxonomic hierarchy. In other words, the family is also a name given to a group which is larger than the genus in its scope and content. Each family is made up of a few or a large number of genera. Thus, just as a genus constitutes several species and the family a group of genera, an order includes one or more related families.

Thus the living world has been divided into two kingdoms, namely,

1. the plant kingdom *invertebrata* and
2. the animal kingdom

The animal kingdom is broadly divided into two sub-kingdoms, namely, 1. the sub-kingdom *invertebrata*, and 2. the sub-kingdom *chordata*. Each sub-kingdom is further divided into many big groups called *phyla* (singular - phylum) based on different plans of organisation. Each phylum is split up for convenience into different classes. The classes are further broken up into orders, on the basis of clearly observable differences. Each order consists of many families, and each family is made up of several genera. Each genus may have many different species. Thus we find a gradation in classification. The units of classification are called *taxa*.

Classification of the pond frog *Rana hexadactyla*

Kingdom	—	Animalis
Sub-kingdom	—	chordata
Phylum	—	chordata
Sub-phylum	—	vertebrata
Class	—	Amphibia
Order	—	Anura
Family	—	Ranidae
Genus	—	Rana
Species	—	hexadactyla

Such arrangement in a particular order, plan or scheme is known as *classification*.

UTILITY OF CLASSIFICATION

Classification is required because of the following reasons:

1. The number of organism is so large and varied and, therefore, it is impossible to study every organism.
2. All the types of the organisms do not occur in a given locality.
3. Without a system of classification it is difficult to recognise or identify different types of organisms.
4. Classification helps in knowing the relationships among different groups of organisms.

1.3 Salient characteristics of major animal groups

You have already learnt that animals are grouped in terms of whether they are *invertebrates* or *vertebrates*. Vertebrates have a vertebral column of bones which supports the

animal body. Invertebrates lack an axial body column. There are, however, certain small groups of animals which have a rod-like supporting column representing the fore-runner of the vertebral column. They cannot be classified as vertebrates, and are known as prochordates.

Activity 1: *Prepare a tree of classification putting in examples of as many animals as you know.*

The major groups in zoology are in terms of whether the animal is

1. single-celled or many-celled, and
2. vertebrate or invertebrate.

The broad phyla or groups are as follows:

1. SINGLE-CELL: *protozoa* (e.g., amoeba)

2. MANY-CELLED:

Invertebrates (animals without backbones)

1. Porifera (e.g., sponges)
2. Coelenterata (e.g., jelly fish)
3. Platyhelminthes (e.g., tapeworm)
4. Nemathelminthes (e.g., Ascaris)
5. Annelida (e.g., earthworm)
6. Arthropoda (e.g., crab)
7. Mollusca (e.g., snail)
8. Echinodermata (e.g., starfish)

Vertebrates (animals with backbones)

1. Class Pisces (e.g., fish)
2. Class Amphibia (e.g., frog)
3. Class Reptilia (e.g., lizard)
4. Class Aves (e.g., pigeon)
5. Class Mammalia (e.g., rat)

Activity 2: *Prepare a poster 'protozoa versus metazoa'.*

Protozoa

Protozoa (Greek, *proto:* first, *zoon:* animal) are acellular, microscopic organisms in which all the vital functions of the animal are carried out in a single cell. The various activities of life are carried on by parts of the cell called organelles. The animals may be sedentary, i.e., non-moving, or capable of locomotion. Locomotion occurs with the help of blunt and temporary out-growths called pseudopodia, several fine thread-like permanent protoplasmic out-growths called cilia,

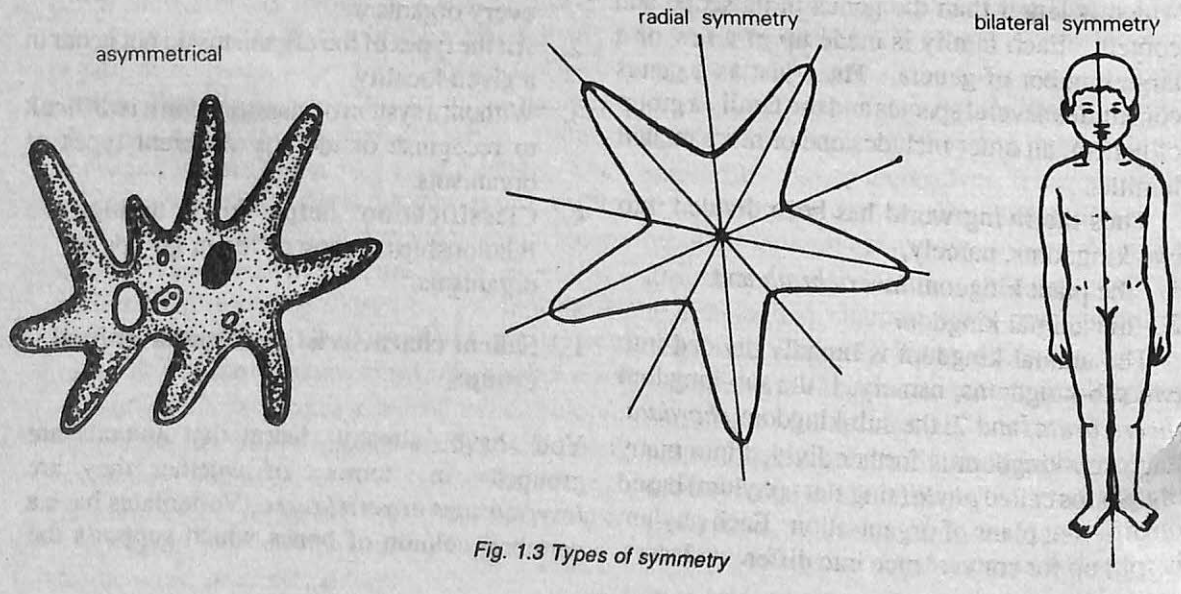


Fig. 1.3 Types of symmetry

a few long protoplasmic threads named flagella or by the contractibility of the cell itself.

Several protozoans have encasements of hard, rigid material which serve to protect the animal. Some organisms produce spores with a resistant covering for protection in unfavourable periods.

Nutritionally, protozoans may be animal-like or plant-like. The plant-like nutrition is described as *holophytic*. This includes the formation of organic food from inorganic raw materials through the process of photosynthesis. The animal-like nutrition can be *saprozoic, parasitic* and *holozoic*. In the saprozoic form animals subsist only on dead animal matter, while parasitic forms obtain their nourishment from another living organism without devouring it. Holozoic nutrition is the typical nutritional mode in animals. In it, bits of solid organic food are taken in or digested.

Protozoans were the first animals to appear on earth. All other animal types have been formed from them through various types and stages of modification. The protozoans reproduce by *fission* and in some cases by *conjugation* and by sexual methods. There is no symmetry. There is no natural death as the mother's body is divided among the offspring.

Examples of protozoans are *amoeba, paramecium, Plasmodium vivax* (the malaria parasite), *euglena* and *vorticella.*

AMOEBA

General characteristics: The amoeba was first reported by Roesel von Rosenhof in 1775. It has attracted the attention of both scientists and laymen because of its everchanging shape and simple structure. It may be regarded as one of the simplest of animals since its body consists of a minute transparent asymmetrical speck of protoplasm with a nucleus but without permanent organelles. Despite its seeming simplicity it performs all the vital activities of life such as movement, nutrition, digestion, assimilation, respiration, excretion,

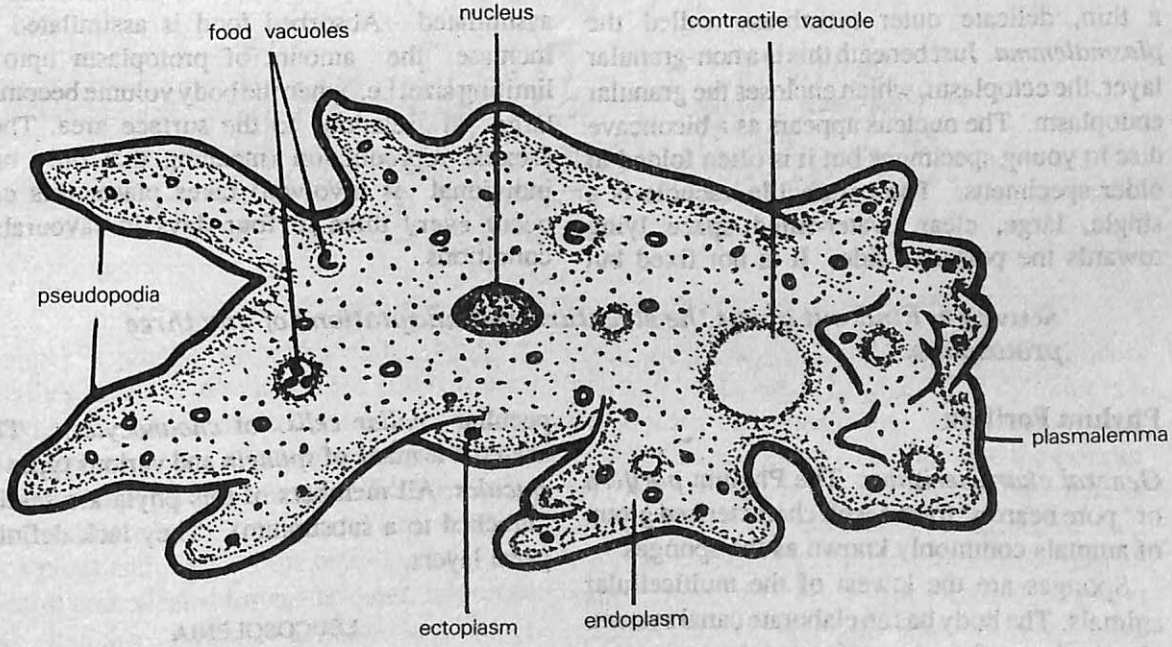


Fig. 1.4 Amoeba proteus

response to stimuli, reproduction and growth. There are several species of amoeba. Of these *Amoeba proteus* is described here.

Habit and habitat: Amoeba proteus is widely distributed. It lives in freshwater pools, ponds, ditches, lakes, slow streams, often in shallow water on the underside of aquatic vegetation. It is also found in damp soil.

Structure and functions: Amoeba proteus is a one-celled animal about 0.25 mm (250 microns) in diameter and so transparent that it is invisible to the naked eye. Under the compound microscope, it appears as an irregular, colourless mass of living animal-like jelly or protoplasm that is constantly changing its shape by sending out and withdrawing finger-like lobes of protoplasm called *pseudopodia.* The name 'amoeba' is derived from a Greek word *amoibe,* meaning 'change'. The specific name 'proteus' is based on the name of a mythological Greek sea god who was believed to constantly change his shape. Although it possesses no cell wall, it has a thin, delicate outer membrane called the *plasmalemma.* Just beneath this is a non-granular layer, the ectoplasm, which encloses the granular endoplasm. The nucleus appears as a biconcave disc in young specimens but it is often folded in older specimens. The contractile vacuole is a single, large, clear, water-filled space lying towards the posterior side. It is not fixed but circulates in the endoplasm. Numerous food vacuoles are scattered in the endoplasm. These are non-contractile and of different sizes. Each food vacuole contains a morsel of food under digestion. The food vacuoles are carried about by the movements of the endoplasm. Digestion of food takes place inside the food vacuole. Amoebae have great powers of regeneration. This power of making up lost parts is well developed in many lower forms.

Amoebae exhibit amoeboid movement. The protoplasm of the endoplasm exists in two different states, *plasmagel* and *plasmasol.* The two states can interchange within themselves and this provides the means of movement. The amoeba captures its prey by means of its pseudopodia.

Nutrition in amoebae is simple. Food is taken into the body and is digested when various enzymes act upon it. It is later egested from any point in its body. Respiration, growth and reproduction take place by inward diffusion. Excretion is by outward diffusion. The process of growth and reproduction is based on the food assimilated. Absorbed food is assimilated to increase the amount of protoplasm upto a limiting size, i.e., when the body volume becomes large in relation to the surface area. Then asexual reproduction (meaning that only one individual is involved) takes place; this can occur every three to four days in favourable conditions.

Activity 3: *Find out about the structure and adaptations of any three protozoans.*

Phylum Porifera

General characteristics: The Phylum *porifera* or ' pore bearers' form a well characterised group of animals commonly known as the sponges.

Sponges are the lowest of the multicellular animals. The body has an elaborate canal system. The body surface is perforated by numerous minute openings. The interior of the body contains peculiar *collar cells* or *choanocytes.* The skeleton is made of *spongin* and various types of *spicules.* All members of this phyla are sessile (attached to a substratum). They lack definite germ layers.

LEUCOSOLENIA

Habit and habitat: A colony of *Leucosolenia*

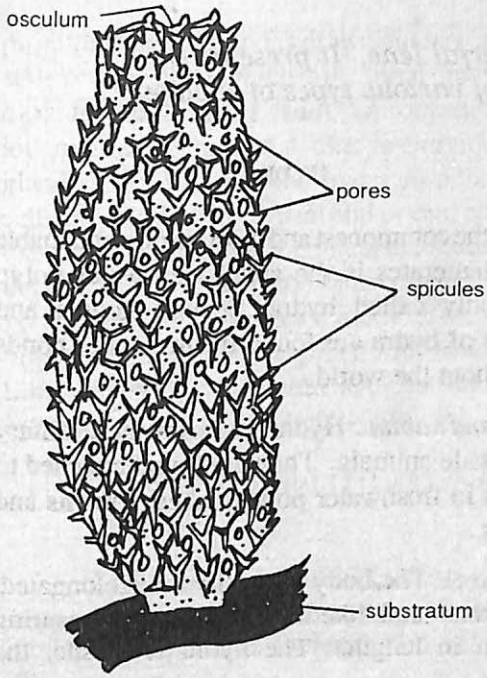


Fig. 1.5 A young ascon sponge

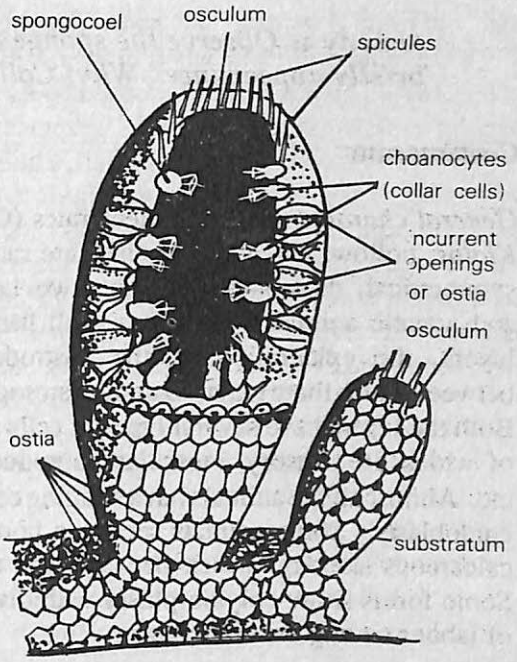


Fig. 1.6 Leucosolenia.

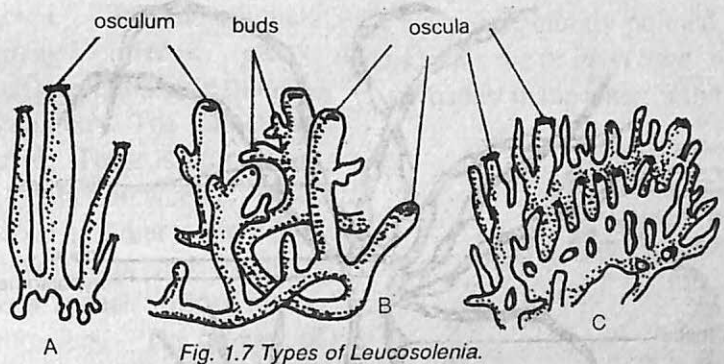


Fig. 1.7 Types of Leucosolenia.
A—simple. B—branched. C—reticulate.

(sponge) is whitish in colour and consists of radially symmetrical vase-shaped vertical tubes or cylinders united at their base by irregular horizontal tubes, and attached to the substratum through adhesive discs. The name 'Leucosolenia' is derived from two Greek words (*leukos*-white; *solen*-pipe) and refers to the pipe-like body. In the most complicated forms, the outermost tubes unite together forming a false surface or *pseudoderm* with a few openings called *pseudopores*.

Structure: The upright branches or cylinders reach up to 25mm is height. Each cylinder is a thin-walled tube enclosing a spacious central cavity, the *spongocoel*. This opens to the exterior by a large, simple opening known as the *osculum* at the top of the distal end. The surface of each cylinder is perforated by numerous minute pores, called the *ostia*, which open into the central spongocoel. A continuous water current passes through the ostia into the spongocoel and out of the osculum.

Activity 4: *Observe the sponge under a powerful lens. It presents a bristly appearance. Why? Collect pictures of various types of sponges.*

Coelenterata

General characteristics: Coelenterates (Greek *Kiolos:* hollow, *enteron:* intestine) are radially symmetrical, diploblastic (having two layers) and aquatic animals. The body wall has two layers, the epidermis and the gastrodermis between which there is a structureless mesogloca. Both the layers have several types of cells some of which are sensory, muscular, reproductive, etc. Almost all the animals have stinging cells or cnidoblasts. Some animals secrete a horny or calcareous skeleton which becomes the coral. Some forms show polymorphism with division of labour among the branches.

HYDRA

One of the commonest and most readily obtainable of coelenterates is the small freshwater polyp commonly called hydra. Several genera and species of hydra are found in freshwater ponds throughout the world.

Habit and habitat: Hydra are freshwater, solitary and sessile animals. They are found attached to objects in freshwater ponds, lakes, streams and ditches.

Structure: The body of the hydra is elongated, cylindrical and like an elastic tube measuring 1-3 cm in length. The hydra is sessile; the

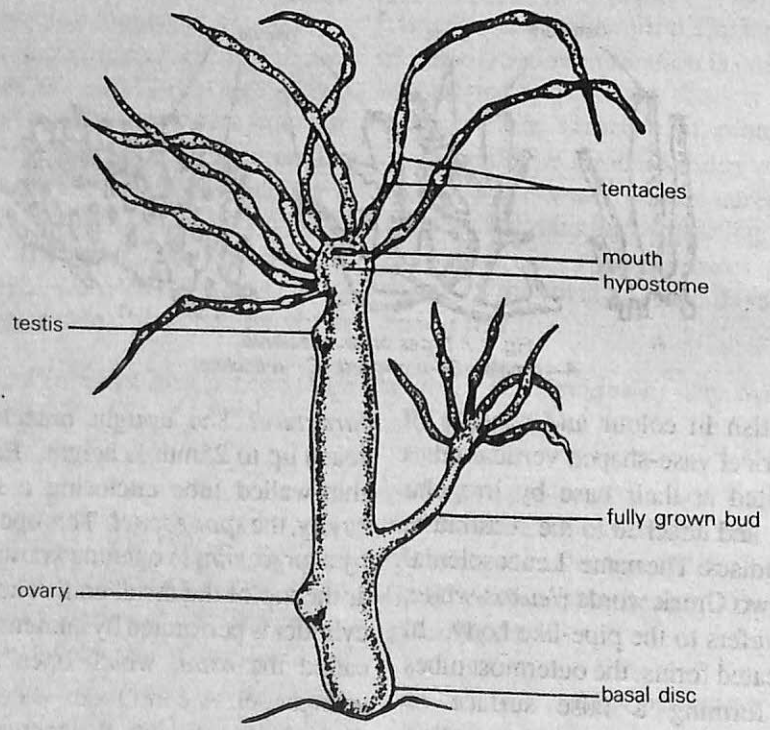


Fig. 1.8 Hydra: external features

proximal or aboral end is drawn out into a slender stalk on the end of which is the basal disc or pedal disc for attachment with an object, or for locomotion. The pedal disc is provided with gland cells to enable the hydra to adhere to a substratum. The free distal end or oral end bears the mouth situated on a conical elevation called the *hypostome*. The hypostome is encircled by 6-10 *tentacles*. The tentacles are hollow, slender, finger-like projections provided with *nematocysts*. Like the body, the tentacles can be greatly extended and may stretch out for several millimeters when the animal is hungry. The mouth opens into the gastrovascular cavity or *enteron* which communicates with the cavities in the tentacles. the tentacles are rich in special stinging cells called nematocysts.

The animal moves from place to place, by gliding, somersaulting or with caterpillar-like movements. The digestion is partly extracellular and partly intracellular. There is a network of nerve cells throughout the body. The animal reproduces asexually by budding and also sexually by forming gametes.

Activity 5: *What is a 'sea rose' ? Find out more information about this animal.*

Activity 6: *Use a dissecting microscope to examine the hydra in a watch glass filled with water. Locate the basal disc, the star-shaped mouth surrounded by tentacles. Can you see the nematocysts?*

Platyhelminthes

General characteristics: Platyhelminthes, meaning 'flat worms' (Greek, *platy:* flat, *helminthes:* worms) are triploblastic animals. They show bilateral symmetry. The animals are dorso-ventrally flattened. There is no coelom, since it is occupied by parenchyma cells. Excretion is effected by peculiar cells called *flame cells* or *solenocytes*. A primitive brain is seen. Reproduction is sexual. Most of the animals are hermaphrodites. The power of regeneration is marked. Adaptation to parasitic existence is well developed in many forms.

THE LIVER FLUKE *(FASCIOLA HEPATICA)*

Habit and habitat: Fasciola hepatica (the sheep liver fluke) lives as an endoparasite in the bile ducts of sheep. The adult flukes are typical parasites of vertebrate animals but one stage of their life history is invariably spent in an invertebrate host—a mollusc. Sometimes the adult flukes invade other cattle, other mammals and occasionally man. The disease caused by the liver fluke is known as *liver rot*.

Structure: Fasciola hepatica has a thin, flattened, leaf-shaped body about 25-30 mm long, rounded anteriorly and bluntly pointed behind. It has a triangular cone or *head lobe* at the anterior end. It is broadest in the anterior third of the body and

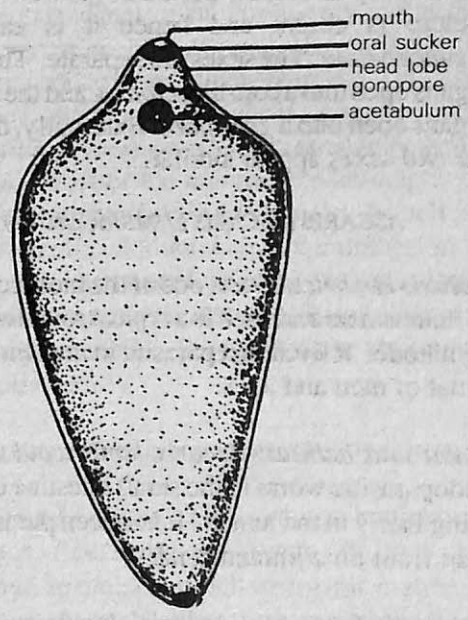


Fig. 1.9 The liver fluke (Fasciola hepatica)

tapers towards the posterior end. There are two muscular suckers, an *oral sucker* at the anterior end enclosing a *mouth*, and a large *ventral sucker* or *acetabulum* behind the head lobe on the ventral side. These suckers are muscular cups for attachment to the host by vacuum. Anterior to the acetabulum is a common *genital aperture* or *gonopore* lying ventrally.

Activity 7: *With the aid of the dissecting microscope, examine planaria in a watch glass filled with water. Observe its bending and twisting movements.*

Nemathelminthes

General characteristics: The animals in this phylum have the following general characteristics. They have a bilaterally symmetrical, cylindrical body with a glistening, smooth surface. Free-living nematodes are found in the sea, freshwater, or in the soil in all kinds of environment, often in enormous numbers. There are also many parasitic nematodes found in all groups of plants and animals, particularly in insects and vertebrates. They show no trace of segmentation. They are generally small-sized, though some attain great lengths. The head is not well-formed. The body is covered by a tough, resistant cuticle which moults only during the period of growth. A true coelom is absent and hence it is called a *pseudocoelom*. The sexes are separate. The male organs open into a coil-like *cloaca*, and the female organs open into a *gonopore*. Externally, though, the two sexes appear similar.

ASCARIS *(ASCARIS LUMBRICOIDES)*

Ascaris lumbricoides is one of the most common of human nematodes. It is a typical roundworm or nematode. It lives as a parasite in the alimentary canal of men and apes.

Habit and habitat: Ascaris lumbricoides is an endoparasitic worm in the small intestine of man, lying freely in the lumen. It has been parasitising man from time immemorial.

External features: Ascaris lumbricoides is elongated, cylindrical and tapering at both ends. It is a large-sized nematode showing sexual dimorphism, i.e., the sexes are separate. The female is 20-49 cm (8-16 inches) long and

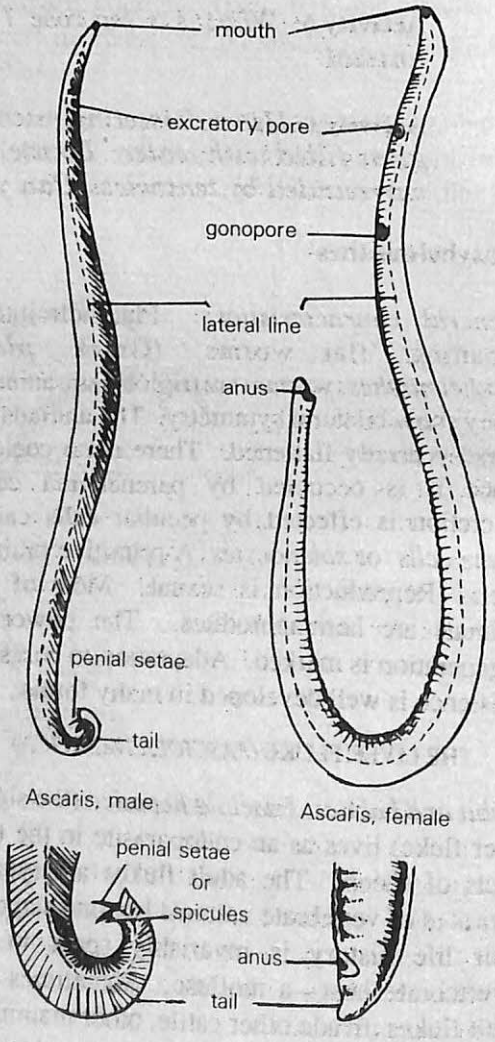


Fig. 1.10 Ascaris lumbricoides

4-6 mm in diameter, but the male is smaller, being 15-31 cm (6-12 inches) and 2-4 mm in diameter.

Generally, nematodes have no colour. The external cuticle is whitish or yellowish but some, like *Ascaris*, have a definite reddish tint caused by the presence of haemoglobin.

Structure: The anterior ends of both the sexes exhibit the same structure. The body is covered with a smooth, tough and elastic cuticle which is striated transversely and gives the worm its pseudo-segmented appearance.

In nematodes the anterior mouth is bounded by six lips, but these are reduced by fusion to three in *Ascaris*, one dorsal and two ventro-lateral in position. The lips bear a few sensory papillae. Just behind the anterior end a small excretory pore is present on the ventral side. The female has a gonopore on the same side, roughly a third of the distance from the anterior end. Near the posterior end is a transverse anus with thick lips, but the male has a cloaca from which two equal chitinous *spicules* or *penial setae* project.

The female carries about 27 million eggs in various stages of maturity. The eggs are passed out from the host along with the stools. The intermediate host is absent. The eggs are covered over by highly resistant shells. They reach human beings through contaminated food. Inside the alimentary canal the larvae is liberated. They penetrate the wall of the alimentary canal and pass into the blood vessels. The larvae or *juveniles* may reach any organ of the body and cause its malfunctioning. *Ascaris* robs the host of its food. The juveniles puncture various organs of the body causing serious wounds.

Activity 8: *Collect information about any three nematode worms and the diseases caused by them.*

Annelids

Early zoologists included the annelids with other worms in the group Vermes but they were separated by Cuvier in 1798 from the group of unsegmented worms. The word *annelida* has been derived either from the Latin *annellus* meaning 'little ring' or the French *anneler* meaning 'to arrange in rings'.

General characteristics: Annelids are triploblastic (three layered), bilaterally symmetrical, coelomate and segmented. The body is segmented both internally as well as externally in the form of rings or annuli *(metameric segmentation)*. The body is covered by a thin cuticle. The body wall is covered with a glandular epidermis, below which are muscles forming an outer layer of circular muscles and an inner layer of longitudinal muscles. The body is divided for the first time in the animal series into metamerically arranged segments or *metameres* arranged in a linear series, but the segments are integrated into a single functional unit.

The digestive tract is complete with a straight alimentary canal. The circulatory and nervous systems are well developed. Excretion is done through coiled tubes called *nephridia*. The nervous system possesses *cerebral ganglia* and a *ganglionic nerve cord*. The vascular system has hearts. Most of the animals are hermaphrodite, i.e., they are both male and female. Annelids are more advanced than nemathelminthes in that they are segmented, having a true coelom, nephridia, and well-developed circulatory and nervous systems. Some animals also possess appendages.

THE EARTHWORM *(PHERETIMA POSTHUMA)*

Habit and habitat: The common earthworm of India is *Pheretima posthuma*. It lives inside burrows in moist soil rich in organic matter. The burrows are made either by their pushing through

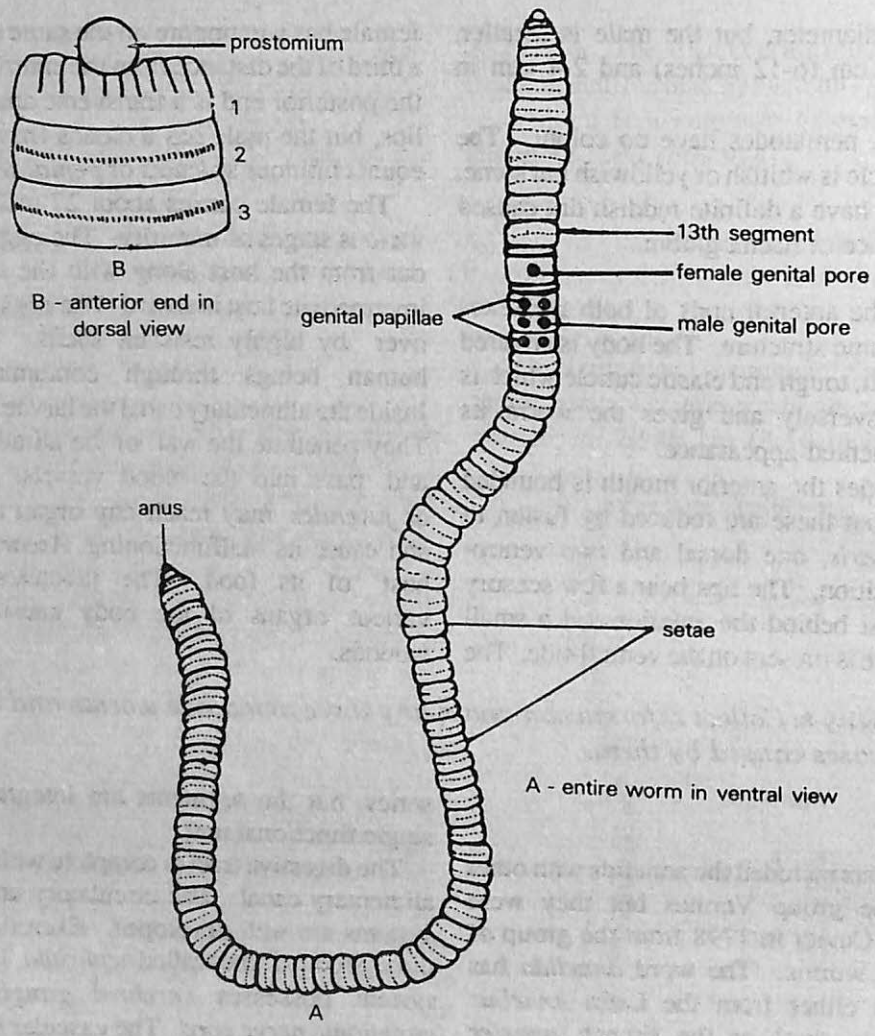


Fig. 1.11 The earthworm (Pheretima posthuma)

the soil or by eating the same. The depth of the burrow depends upon the season. The entrance of the burrow is usually covered by faecal balls or worm castings. The animals leave their burrows during the rainy season.

Earthworms are cosmopolitan in distribution i.e., found almost all over the world except in the Arctic and Antarctic regions.

Structure: Pheretima posthuma has a long narrow body which is bilaterally symmetrical. The anterior end is tapering while the posterior end is more or less blunt. The thickest part of the body is always situated a little behind the anterior. The dorsal surface is easily distinguished by the presence of a dark median line of the dorsal blood vessel which runs throughout the length of the body just below the skin while the ventral surface is distinguished by the presence of genital openings and papillae in the anterior part of the body. The size varies from species to species. A mature earthworm may attain a length of upto 150 mm and a thickness of 3 to 5 mm.

The worm is glistening, dark-brown in colour. The dorsal surface is darker than the ventral surface.

Activity 9: *Get an earthworm from your garden. Observe the segments, the anterior and posterior regions and clitellum.*

In the earthworm the segmentation of the body is true, i.e., the external segmentation corresponds with internal segmentation. The whole surface of the body is divided by a distinct series of circular furrows into a series of ring-like segments or metameres. This constitutes the external segmentation. Similarly the interior of the body is divided by septa and this is called internal segmentation. A few segments of the anterior end may be subdivided externally into two or three annuli. Such segments are said to be *biannulate* or *triannulate*. These annuli are formed by mere superficial furrows.

The anterior end of the animal has a small fleshy lobe, the *prostomium*, which is not a segment. It is separated by a groove from the first segment; such a prostomium is called the *pre-epilobous*. In the mature worm, there is a prominent circular band of glandular tissue known as the *clitellum* which completely surrounds segments 14-16 forming a girdle around the body. The glands of the clitellum secrete mucus.

In all the segments except the first, last and the *clitellum* there is a ring of chitinous *seta* lying embedded in the middle of each segment. These setae project backward. Each seta arises from a sac of the skin and is a pale yellow, curved, S-shaped structure with a swollen middle part called the *nodulus*.

Fig. 1.12 The earthworm: body seta

The *mouth* is a crescentric aperture situated just below the prostomium and surrounded by the first segment of the body called the buccal segment or *peristomium*. The *anus* is that aperture by which the undigested wastes are removed. It is a terminal opening which is present in the last segment of the body called the anal segment, and the opening is known as the anus or anal aperture.

The earthworm is a hermaphrodite and so male and female generative apertures are found in the same individual. On the 18th segment ventrally there is a pair of crescentric openings called the *male genital pores* or apertures through which the male reproductive bodies are discharged. On the ventral side of the clitellum in the 14th segment there is a median aperture through which the female reproductive bodies are discharged.

There are four pairs of small ventro-lateral *spermathecal apertures* lying intersegmentally between the grooves of segments 5/6, 6/7, 7/8 and 8/9 (see Fig. 1.11). A large number of very minute *nephridiopores* are found on the body of the earthworm. Through these pores the integumentary nephridia, which are found scattered throughout the body except in a few of the anterior segments, communicate to the exterior through which the metabolic wastes of the body are removed.

Situated along the mid-dorsal line in the inter-segmental grooves are a series of minute openings, the *dorsal pores*, which lead directly into the body cavity.

Genital or copulatory papillae: In the same line with the male pores, on the ventral side of each of the 17th and 19th segments, there is a pair of circular and raised papillae; these are the genital or copulatory papillae. During copulation, the genital papillae function as suckers.

The earthworm feeds on dead organic matter,

fallen leaves, algae, etc. It has a separate digestive system. This annelid respires cutaneously. Excretion is carried out by a number of coiled tubes called *nephridia*. The nervous system consists of a nerve ring, a nerve cord, and a number of peripheral nerves.

Arthropods

General characteristics: The phylum arthropoda (Greek *arthros:* jointed, *podos:* foot) is the largest group in the animal kingdom. It surpasses all others both in number of individuals and in the diversity of their ecological distribution. They are characterised by bilateral symmetry, three germinal layers, external segmentation and well-developed sense organs. They body is covered over by a exoskeleton of chitin. The digestive system is complete. The true coelom is very small. The main body cavity is filled up with blood and is called *haemocoel*. The circulatory system is of the open type and closed vessels are absent. Excretion takes place through green glands or *malpighian tubules*. The respiratory organs may be of three types—gills, book lungs and tracheae. The sexes are separate.

Insects or arthropods have three pairs of jointed legs and a body which is divided into three parts —the *head, thorax* and *abdomen*. The head has a pair of long antennae or feelers, a pair of compound eyes and a set of mouth parts for chewing, biting, piercing or sucking. The compound eyes contain a number of units called *ommatidia*. Each ommatidium has on the outside a biconvex but hexagonal corneal lens. An object is therefore viewed by the insect in a wide arc. The images of these parts produce a mosaic vision.

The thorax usually has two pairs of wings. These may be *mesothoracic* or *metathoracic*. They arise from the middle and posterior segments of the thorax.

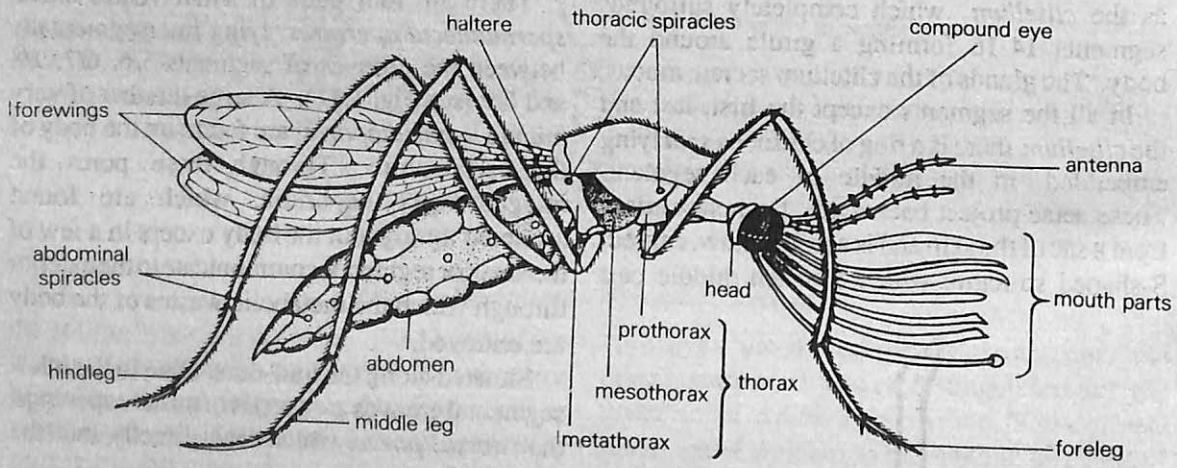


Fig. 1.13 The culex mosquito: external features

The abdomen is usually without any appendage and is segmented. Both the abdomen and thorax bear lateral pores called *spiracles*.

The body of an insect and other arthropodes is surrounded by a rigid exoskeleton of chitin. It is elastic within a narrow range. Therefore, during growth, an insect casts off its exoskeleton occasionally. This phenomenon is called *moulting* or *ecdysis*.

THE CULEX MOSQUITO (*CULEX PIPIENS*)

Habit and habitat: The *Culex pipiens* is found in temperate regions all over the world. The culex lives in houses, in cities and farms, and is abundant

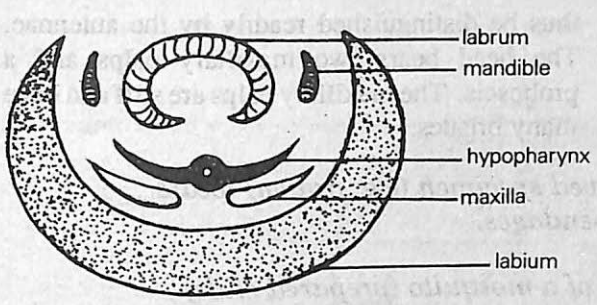


Fig. 1.14 The mouth parts of the mosquito in cross-section

in rural areas. The life span of the male mosquitoes is seldom more than three weeks. They die after fertilising the eggs in the females. The females live from four weeks to several months, but they die when all their eggs are laid.

Structure: The body of the culex is small, soft, slender and covered with small scales. The body is grey in colour and measures about 3 to 4 mm in length.

The body is divisible into the *head, thorax* and *abdomen.*

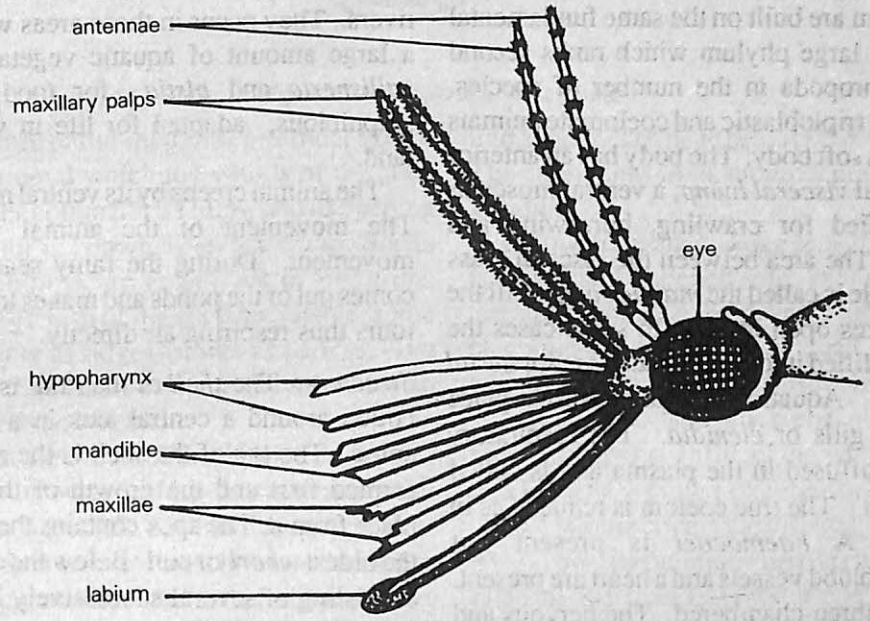


Fig. 1.15 The mouth parts of the mosquito: left view

The head is globular and highly mobile on a slender neck. There are two very large, black, compound eyes. There are two filiform antennae, each with 15 joints. The basal segment is the *scape* which is concealed by a very large globular second segment, the *pedicel.* This contains a Johnson's organ which is auditory in function. The other 13 joints form a *flagellum* with many bristles lying in rings.

The *proboscis* is a straight, long tube formed by a fleshy ventral labium which has a deep groove on its upper side. In this groove is a long, pointed and ventrally-grooved *labrum epipharynx.* At the distal end of the labium is a pair of small tactile labella which are reduced labial palps. The groove of the labium also contains five needle-like stylets. In a female culex, there are two *mandibles,* two *maxillae,* and a *hypopharynx.* The mandibles are finer than the maxillae, but both have saw-like edges on their

tips. The bristles are longer and much more numerous on the antennae of males giving them a bushy appearance. In the female the antennae have rings of a few, short bristles. The sexes can thus be distinguished readily by the antennae. The head bears two maxillary palps and a proboscis. The maxillary palps are stiff and have many bristles.

Activity 10: *On a living (or) a preserved specimen (e.g. prawn) locate the carapace, feathery gills and appendages.*

Activity 11: *Observe the mouth parts of a mosquito (prepared slide) under the microscope.*

Molluscs

General characteristics: Molluscs appear to be a heterogenous group with great diversity of form, but all of them are built on the same fundamental plan. It is a large phylum which ranks second only to Arthropoda in the number of species. Molluscs are triploblastic and coelomate animals which have a soft body. The body has an anterior *head*, a dorsal *visceral hump*, a ventral muscular *foot* modified for crawling, burrowing and swimming. The area between the visceral mass and the mantle is called the *mantle cavity*. All the body apertures open into it. In some cases the cavity is modified into a *pulmonary sac* for *aerial respiration*. Aquatic respiration takes place through the gills or *clenidia*. The respiratory pigment is diffused in the plasma and is called *haemocyanin*. The true coelom is reduced as in arthropods. A *haemocoel* is present but additionally blood vessels and a heart are present. The heart is three-chambered. The nervous and digestive systems are well-developed.

Molluscs are mostly marine, though some are found in fresh water and a few are terrestrial. The members of this phylum show a great diversity of form. They include such familiar animals as snails, clams or mussels, oysters, squids and octopods.

THE APPLE-SNAIL *(PILA GLOBOSA)*

Pila is commonly known as the apple-snail. The common species found in Northern India is *Pila globosa*.

Habit and habitat: Pila globosa or the apple-snail is one of the largest freshwater molluscs. It is commonly found in freshwater ponds, pools, tanks, lakes and sometimes even in streams and rivers. They occur in those areas where there is a large amount of aquatic vegetation such as *vallisneria* and *pistia* for food. They are amphibious, adapted for life in water and on land.

The animal creeps by its ventral muscular foot. The movement of the animal is a gliding movement. During the rainy seasons the Pila comes out of the ponds and makes long terrestrial tours thus respiring air directly.

Structure: The *shell* of the *Pila* is univalve but coiled around a central axis in a right-handed spiral. The top of the shell is the apex which is formed first and the growth of the shell takes place from it. The apex contains the smallest and the oldest *whorl* or coil. Below the apex is a spire consisting of several successively larger whorls followed by the largest whorl or *body whorl* which encloses most of the body. The lines between the whorls are called *sutures*. The body whorl has a large mouth or opening. The margin of the mouth is called a *peristome* from which the head and the foot of the living animal can protrude. When viewed from the ventral side with the peristome facing the observer, the mouth lies to the right of the columella and the shell is spirally clock-wise, then it is spoken of as being right-handed or *dextral*. The outer margin of mouth is called an *outer lip* and the inner margin an inner or *columellar lip*.

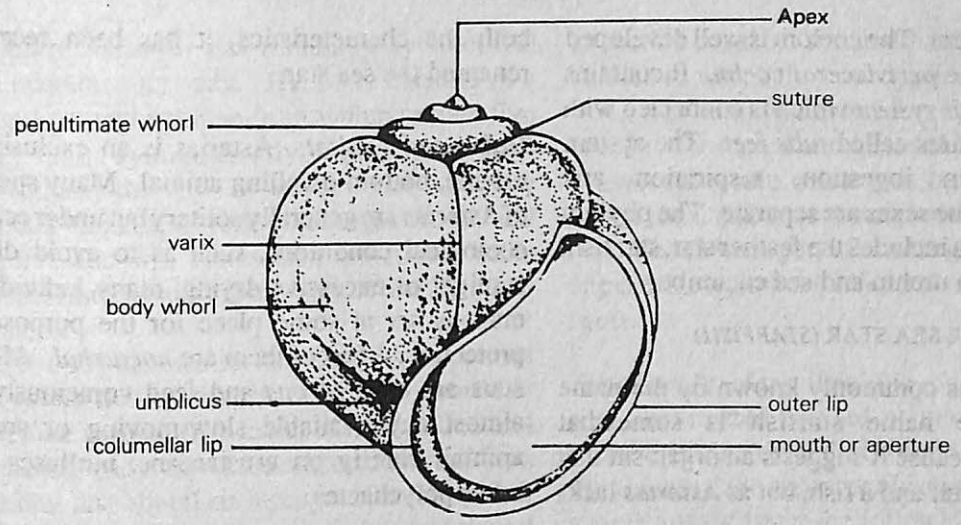


Fig. 1.16 The apple snail (Pila globosa)

In the centre of the shell runs a vertical axis or columella around which the whorls of the shell are coiled; the columella is hollow and its opening to the exterior is known as an *umbilicus*. Shells with an umbilicus are *umbilicate* or *perforate*. The lines of growth of the shell are visible, some of them appear as ridges known as *varices*. The shell of the *Pila* varies in colour from yellowish to brown or even blackish.

Fitting into the mouth of the shell is a calcareous *operculum*. Its outer surface shows a number of rings of growth around a nucleus; the inner surface has an elliptical boss for attachment of muscles. The boss is cream-coloured and is surrounded by a groove.

The body consists of a head, a foot and a visceral mass. There is a distinct *head* produced into a snout. The head bears two pairs of *tentacles*. The animal has in its mouth a grasping organ or a *radula*.

Below the head is a large *foot*, its lower surface is a grey and flattened sole. It is triangular with the apex pointing backwards and is used for creeping. In the foot is a pedal mucous gland which forms a slime tail during locomotion.

Above the head is a *visceral mass* containing the main organs. It fill all the whorls of the shell and is spirally coiled like the shell.

The *mantle* covers the visceral mass and forms a hood over the animal when it is withdrawn. The edge of the mantle is thick and contains *shell glands* which secrete the shell.

All the other systems are well-developed. The sexes are separate.

Activity: 12: *Place a live octopus in a glass trough, place some objects like a ball near it. Observe the movement of the octopus and how it holds objects. Record the behaviour of the octopus.*

Echinodermata

General characteristics: Echinoderms are exclusively marine and are among the most common and widely distributed of marine animals. They are coelomate animals with pentamerous radial symmetry — that is, the body can be divided into five parts arranged around a central axis, but the larva is bilaterally symmetrical. There is no head. There is an exoskeleton of calcareous *ossicles;* there are also external spines which may be movable or fixed.

The head is absent. The coelom is well developed and is called the *perivisceral coelm.* It contains a *water vascular system* which is connected with peculiar structures called *tube feet.* The system takes part in ingestion, respiration and locomotion. The sexes are separate. The phylum Echinodermata includes the feather star, star fish, brittle star, sea urchin and sea cucumber.

THE SEA STAR *(STARFISH)*

The *Asterias* is commonly known by the name starfish. The name starfish is somewhat mislea[illegible] because it suggests an organism that is both [illegible]e a star and a fish, but as *Asterias* lacks both the characteristics, it has been recently renamed the sea star.

Habit and habitat: Asterias is an exclusively marine, bottom-dwelling animal. Many species of *Asterias* are generally solitary but under certain ecological conditions, such as to avoid direct sunlight or excessive drying, many individuals may gather at some place for the purpose of protection. Most of them are *nocturnal.* All sea stars are *carnivorous* and feed voraciously on almost any available slow-moving or sessile animal, chiefly on crustaceans, molluscs and other polychaetes.

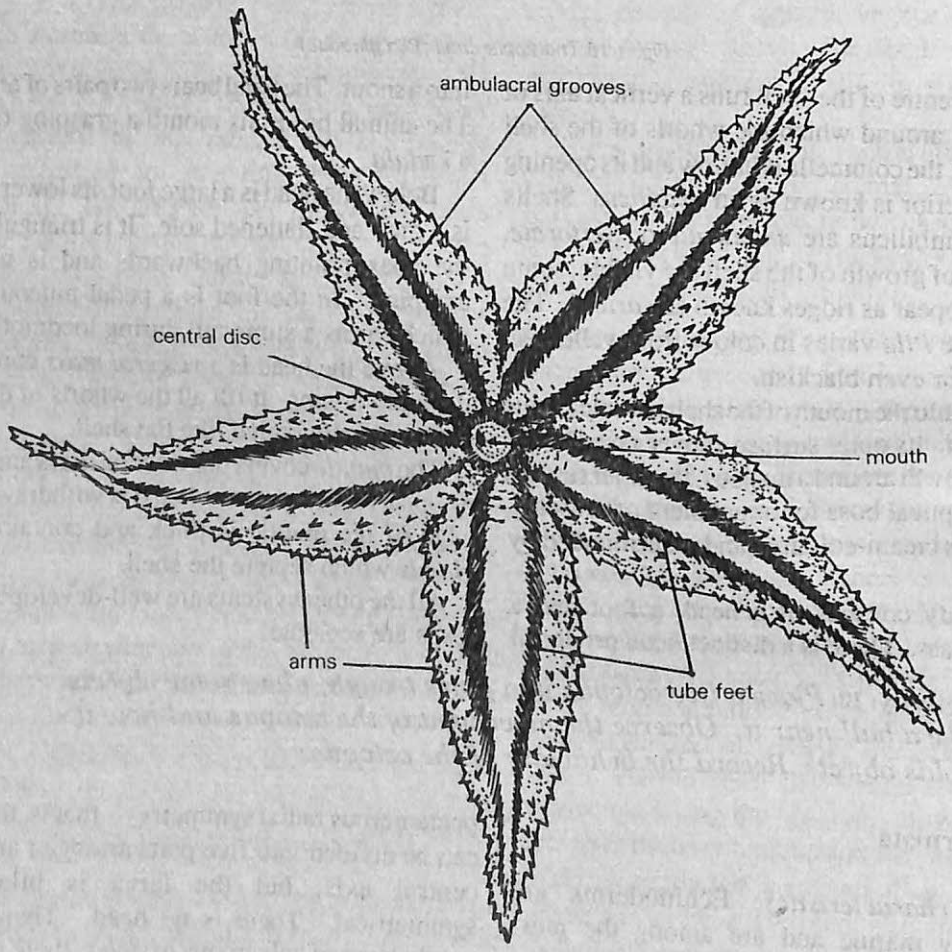


Fig. 1.17 The sea star: external features

Structure: Asterias has a radially symmetrical and pentamerous body. The body consists of a central pentagonal disc from which radiate five elongated, symmetrically tapering spaced projections, the *rays* or *arms*. The colour is variable: shades of yellow, orange, brown and purple. The size varies from 10 to 20 cm in diameter though some forms may be much smaller or bigger.

The body has two surfaces, the upper convex and much darker side is called the *aboral* or *abactinal* surface. The lower surface is flat, less pigmented and is called the *oral* or *actinal* surface. The oral and aboral surfaces are not the ventral and dorsal surfaces but correspond to the left and right sides of the bilaterally symmetrical larva. The axes occupied by the arms are known as *radii* and the regions of the central disc between the arms as *inter-radii*. A well-defined head is absent.

The oral surface: The side of the body in natural conditions remains towards the substratum and contains the mouth or oral opening. It is flat, of a dark orange colour and is called the *oral* or *actinal surface*. The oral surface bears the following structures:

1. The mouth: On the oral surface, in the centre of the pentagonal central disc is an aperture, the *actinosome* or mouth. It is a pentagonal aperture with five angles, each directed towards an arm. The mouth is surrounded by a soft and delicate membrane, the peristomial membrane or *peristome* and is guarded by five groups of *oral spines* or *mouth papillae*.

2. The ambulacral grooves: From each angle of the mouth radiates a narrow groove called the *ambulacral groove* which runs all along the middle of the oral surface of each arm.

3. The tube feet or podia: Each ambulacral groove contains four rows of locomotor, food-capturing, respiratory and sensory organs called *tube feet* or *podia*. The tube feet are soft, thin-walled, tubular, retractile structures provided with *terminal discs or suckers*. The suckers function as suction cups to afford a firm attachment on the surface to which they are applied.

4. The ambulacral spines: Each ambulacral groove is bordered and guarded laterally by 2 or 3 rows of movable, calcareous, *ambulacral spines* which are capable of closing over the groove.

5. The sense organs: Sense organs include five unpaired *terminal tentacles* and five unpaired *eye spots*.

The aboral surface: The side of the body, which remains directed upward or towards the upper surface, is convex and of a light orange colour. This is called the aboral or abactinal surface. The aboral surface bears the following structures:

1. The anus: A minute circular aperture, called the *anus*, is situated close to the centre of the central disc of the aboral surface.

2. The madreporite: At the aboral surface of the central disc occurs a flat, sub-circular, asymmetrical and grooved plate called the *madreporite* plate or madreporite between the bases of two of the five arms. The madreporite is a sieve-like porous plate leading to the water vascular system.

3. Spines: The entire aboral surface is covered with numerous short, stout, blunt, calcareous spines or tubercles. The spines are variable in size and are arranged in irregular rows running parallel to the long axes of the arms.

4. Papulae or gills: Between the ossicles of the integument are present a large number of minute *dermal pores*. Through each dermal pore projects a very small delicate, membranous and retractile projection called the *dermal branchia* or *gills* or *papula*.

5. The pedicellariae: Besides the spines and gills, the entire aboral surface is covered by many whitish modified spine-like tiny pincers or jaws called *pedicellariae*. They serve as defensive organs and provide protection to the general body surface by keeping the body surface free from debris.

Activity 13: *Observe the morphological features of sea lily, sea cucumber, sea urchins, etc. Examine the preseved specimens in your laboratory and write a short note on each.*

Chordata

General characteristics: Phylum chordata (Greek, *chorda:* string) is distinguished from other phyla of kingdom Animalia by three characteristics — the presence of a notochord, gill slits and a dorsal hollow system. The *notochord* (Greek, *notos:* back, *chorda:* string) is a rod-like structure which consists of large and turgid cells. They are covered over by two sheaths. The notochord persists throughout the life of some chordates but in a majority it is replaced in the adult form by a vertebral column.

The gill slits occur in pairs. They are found in the adults of only the prochordates and fish. The slits function in respiration by serving as outlets for water.

The nerve cord is a hollow tube which lies dorsal to the notochord. In the lower chordates its anterior end enlarges into a small cerebral vesicle. In the higher forms it develops into the brain. The posterior tubular region then gives rise to the spinal cord. Both the spinal cord and the brain are protected by cartilaginous or bony coverings called the *vertebral column* and *cranium*, respectively.

There is a distinct *hepatic portal system.* (Blood from the alimentary canal is taken to the liver and from there, it is taken to the heart.) There is a *post-anal tail.* Animals do not have more than two pairs of limbs. The *respiratory pigment* is found in the corpuscles of the blood.

Class Pisces

General characteristics: This class includes cartilaginous fish like the shark, and bony fishes like the mullet. These fish are characterised by the presence of true jaws and a streamlined body differentiated into a head, trunk and tail. There is a covering of scales which may be partially or completely embedded in the skin. The body has a number of fins. These include a pair each of *pectoral* and *pelvic fins,* one or two unpaired *dorsal fins*, a ventral fin and a tail fin. The fins are meant for balancing and steering.

All fish have lateral-line sense organs. There is a pair of nostrils, a pair of eyes and a mouth situated at or near the tip of the head. 5-7 pairs of *gill slits* are present. These gill slits are covered over by a gill cover known as the *operculum.* Respiration is through the gills. The heart of the fish is two-chambered. The auricle receives deoxygenated blood which is pumped by the ventricle to the gills. In several fish the air bladder is present. Lung fish can have an aerial mode of respiration. The sexes are separate. The fishes are both *viviparous* and *oviparous.* They are *cold blooded.*

THE SHARK *(SCOLIODON SORRAKOWAH)*

Structure: There are several species of sharks. The shark grows upto a length of two feet. It has a long spindle-shaped body, which tapers at both ends and so offers little resistance to water in swimming. The body is divisible into the *head,* the *trunk* and the *tail.*

The head is depressed and protrudes as a snout. The trunk is elliptical in section, and is slight flattened from side to side. The tail is narrow and laterally compressed. The colour of the body is dark-grey above and paler below.

The fish has a covering of scales which form an exoskeleton for the animal. The scales of the shark consists of *minute spines* borne on broad *basal plates.* Such scales are known as *placoid scales.*

Fins are characteristic of fish. They are flattened expansions of the skin supported by skeletal rods. Two sets of *fins* are present, the unpaired or *median fins* and paired or *lateral fins.*

Activity 14: *Get a shark from a fishmonger. Observe the well-developed caudal or tail fin. Rub your finger along its skin noting the sandpaper-like texture due to the presence of scales.*

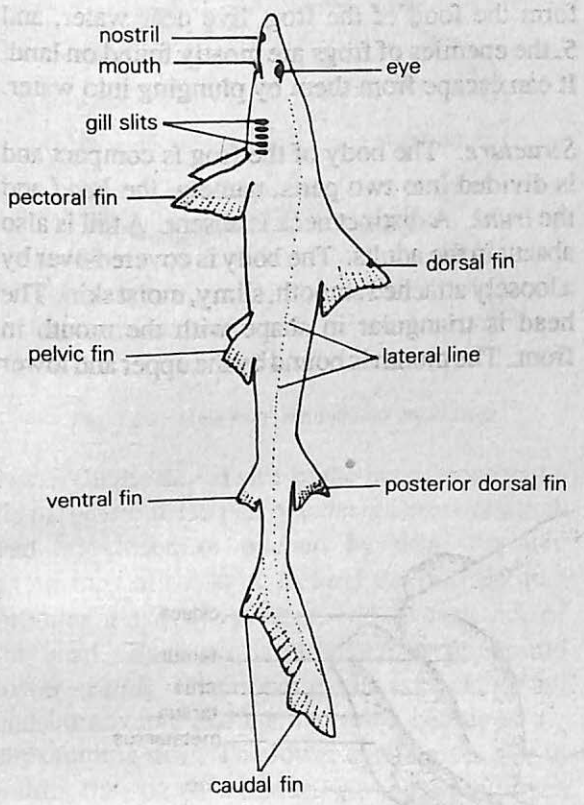


Fig. 1.18 The shark (Scoliodon sorrakowah): external features (lateral view)

In the shark, the median fins consist of two dorsal fins situated on the dorsal surface, a *caudal fin* fringing the tail, and a *ventral fin* lying ventrally behind the cloacal aperture. The lateral fins consist of *paired pectoral fins* and *pelvic fins* which are homologous with the fore and hind-limbs of the frog.

The *mouth* is crescent-shaped and lies on the ventral side. It is bounded by the upper and lower jaws which bear one or two rows of teeth. On either side of the head is a large eye; an upper and a lower eyelid are present, associated with each eye, but they are reduced and immovable. There is, in addition, a third eyelid called the *nictitating membrane,* which can be drawn over the eye from below. Ventrally, in front of the mouth, are the two nostrils. Between the mouth and the pectoral fins, situated laterally, are the gills-slits, five on each side. These lead internally into the pharynx. The cloacal aperture is situated ventrally between the pelvic fins. Extending from the head to the tail along each side is a longitudinal line, called the lateral-line, beneath which lies a canal enclosing special sense organs known as the lateral-line sense organs.

Activity 15: *Collect information about any two cartilaginous fish and bony fish. Try to differentiate between them.*

Class Amphibia

General characteristics: Amphibians (Greek, *amphi:* both, *bios:* life) have characters of both aquatic and terrestrial animals. They live in or near water for the purpose of respiration, breeding and feeding. The amphibians have a moist and glandular skin (which does not possess scales, feathers or hairs), two pairs of clawless limbs and a three-chambered heart. Their body temperature changes according to that of the environment. Such animals are called poikilotherms. Most of the amphibians enter deep into lakes or moist soil during the winter. The phenomenon is known as hibernation or winter sleep. A few amphibians show sluggishness during the hot periods. They rest in moist, shady or cool places. This habit is called *aestivation.*

The animals have two pairs of limbs except in certain species. They are *oviparous.* The heart has three chambers, namely, two auricles and one ventricle.

Activity 16: *Collect pictures of tailed amphibians and the animals which lose their tails during metamorphosis.*

THE FROG *(RANA HEXADACTYLA)*

Habitat: There are several species of frogs, the commonest of which are *Rana hexadactyla* characteristed by six toes in the hind limbs *(hexa:* six; *dactly:* digit). *Rana hexadactyla* lives in or near ponds, ditches, and wells. The reasons for its living in and near water are:

1. Water is the natural breeding place of the animal; 2. the larval stage is passed under water; 3. the skin of the frog is a respiratory organ and, therefore, it must be kept moist by occasional dips in water; 4. worms, insects, snails etc., which form the food of the frog, live near water, and 5. the enemies of frogs are mostly found on land. It can escape from them by plunging into water.

Structure: The body of the frog is compact and is divided into two parts, namely, the *head* and the *trunk*. A distinct neck is absent. A tail is also absent in the adults. The body is covered over by a loosely attached smooth, slimy, moist skin. The head is triangular in shape with the mouth in front. The mouth is bound by the upper and lower

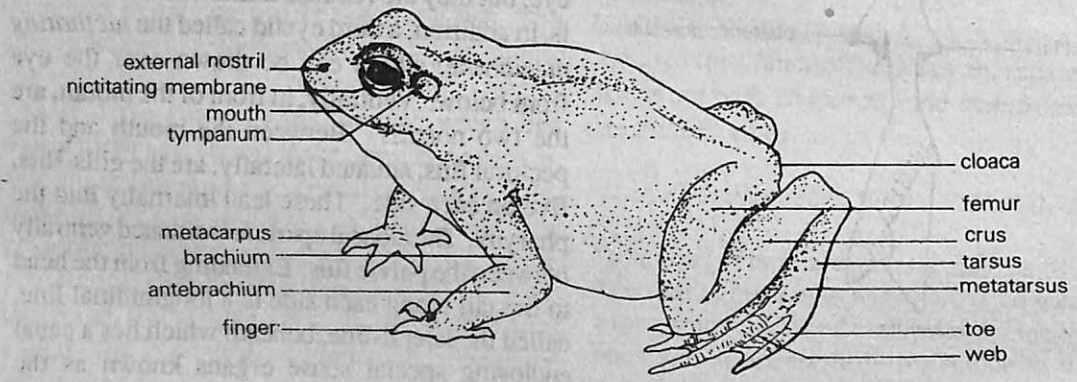


Fig. 1.19 The frog (Rana hexadactyla)

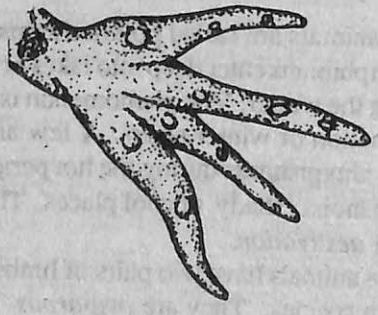


Fig. 1.20 The hand of a female frog

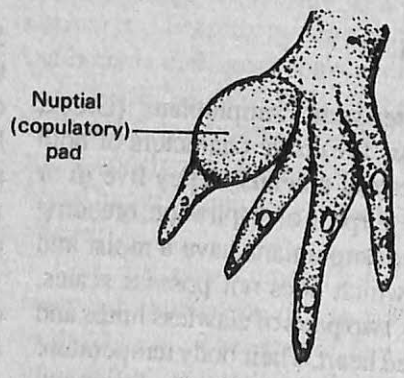


Fig. 1.21 The hand of a male frog

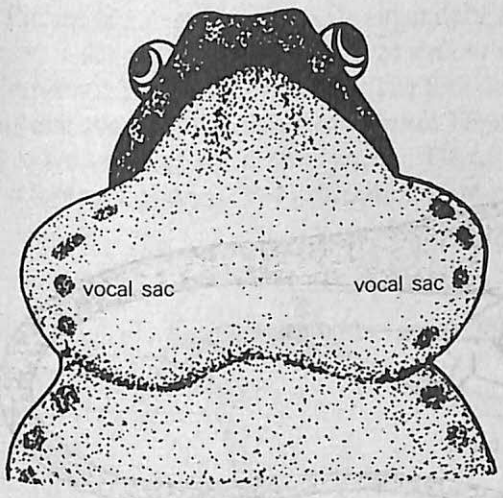


Fig. 1.22 Male frog with inflated vocal sacs

jaws. On the dorsal side of the head, close to the tip of the snout, is a pair of *external nostrils* which can be closed or opened by thin, flap-like extensions of the skin. Behind the nostrils, two prominent *eyes* are present, one on each side of the head. Each eye is protected by upper and lower *eyelids*. The upper eyelid is thick, fleshy and immovable and has the same colour as the surrounding skin. The lower eyelid gives rise to a thin, transparent *nictitating membrane* which functions as a protective structure. Behind each eye, there is a dark, circular patch of stretched skin known as the *tympanic membrane* or the *ear drum*.

The trunk is broad and somewhat flattened and bears two pairs of limbs on the sides. The forelimbs are short and are situated anteriorly while the hindlimbs are longer and adapted for jumping. Each forelimb consists of an *upper arm* or *brachium*, the *forearm* or *antebrachium* and the hand or *manus*. The hand is made up of the wrist or *carpus*, the palm or *metacarpus* and the fingers or *digits*. There are only four fingers in each forelimb.

Each hindlimb consists of three divisions, namely, the *thigh* or *femur*, the *shank* or *crus* and the *foot* or *pes*. The foot is made up of the ankle or *tarsus*, the instep or *metatarsus*, and the toes or *digits*. There are five webbed toes in each hind limb which aid in swimming. There is one reduced toe which is called a *calcar* in this species. At the posterior end of the trunk is a small aperture called the *cloacal aperture*. The frog exhibits sexual dimorphism. The male can be distinguished from the female by the presence of a pair of a thick pad of tissue on the index finger called the *nuptial pad*.

Activity 17: *Observe the nuptial pad and vocal sacs of male frogs.*

Class Reptilia

General characteristics: Reptiles resemble amphibians in being cold-blooded or poikilothermal. They differ from them in having a cornified skin epidermis which is, therefore, dry. The skin bears *scales*. The limbs are *pentadactyl*. They bear *terminal claws*. The animals lay eggs. The heart has two *auricles* and one *ventricle* which is imperfectly divided into two. Reptiles have organs for internal fertilization. Numerous teeth or jaw bones are found in both jaws.

THE GARDEN LIZARD *(CALOTES VERSICOLOR)*

Habitat: The garden lizard is found in gardens, hedges and jungles. It has a light brown or grey colour.

Structure: The body of the garden lizard is divisible into the head, the trunk and the tapering tail. The head is connected with the trunk by a distinct neck. The mouth is at the anterior end. The *cloacal aperture* is a transverse slit on the ventral side at the root of the tail. The body is covered with *horny scales* and thus different

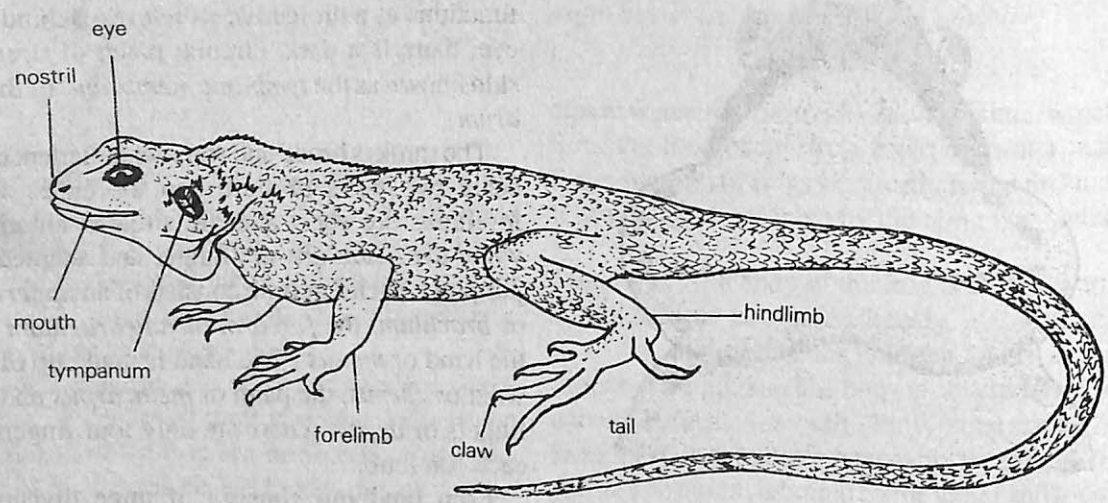


Fig. 1.23 The garden lizard (Calotes versicolor)

from the dermal scales of the fish.

The head: Situated dorsally at a short distance from the anterior end are the external nostrils. On either side of the head are the two eyes, each with a thick *upper lid*, a thin *lower lid* and a transparent *nictitating membrane*. The *auditory apertures* lie behind the eyes, and the *tympanic membrane* lies tightly stretched over each aperture. Teeth are present in the margins of both jaws. The trunk bears two pairs of limbs towards its ventral side. The forelimb consists of the upper arm or *brachium*, the forearm or *antebrachium*, and the hand or *manus*. The hand bears five digits ending in claws. The hindlimb also shows similar divisions — a proximal thigh or *femur*, a middle shank or *crus* and a distal foot or *pes*. The foot bears five toes which are all clawed.

Activity 18: *Collect pictures of house lizards, monitors, turtles and snakes, and write a short note on their external features.*

Activity 19: *Observe the large ventral scales (scutes) of the preserved specimens of snakes. What are they used for?*

Class Aves

General characteristics: Birds are terrestrial or arboreal. They are characterised by the presence of an exoskeleton of feathers. There are four types of feathers — contour feathers, down feathers, filoplumes and bristles. The contour feathers cover the general surface of the body. The wing feathers are called *remiges* and the tail feathers are known as *rectrices*. The down feathers occur below the contour feathers. They are most abundant in the breast region. The forelimbs are modified into wings. The body of a bird is streamlined. It is also light because of the presence of air sacs. The red blood corpuscles are nucleated. The animals have a constant body temperature, hence they are warm-blooded or *homoiothermal*. Teeth are absent. The head is extended into a beak. Respiration is by lungs which have air sacs attached to them. The heart has four chambers, two auricles and two ventricles. The food tract of a bird possesses a crop at the base of the oesophagus for storing food. There is an additional chamber, attached to the stomach, called a *gizzard*. The gizzard is meant for grinding food.

Pinnae are absent. Both the brain and the eyes are well-developed. The eyes have a *nictitating membrane*. The neck is flexible. The female has only one ovary. All birds are *oviparous*. The eggs are covered over by a hard shell. There is a development of *amnion*. Fertilisation is internal.

THE PIGEON *(COLUMBA LIVEA)*

External characteristics: The body of the pigeon is divisible into a more or less round head, a long mobile neck, a short trunk and a stumpy tail. The head is drawn out in front into a beak, and

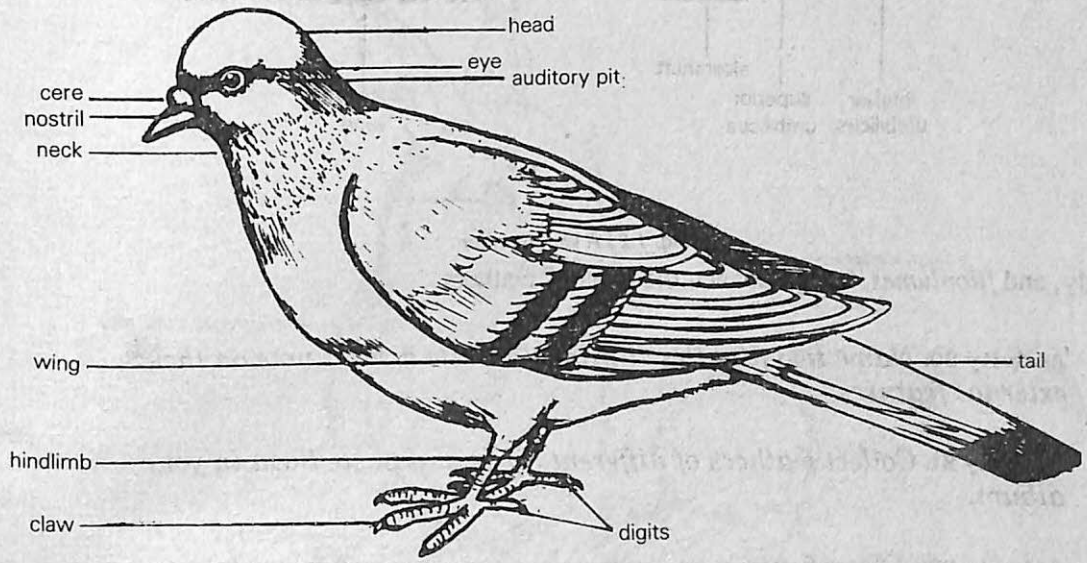


Fig. 1.24 The pigeon (Columba livea)

contains the mouth which is a slit-like opening. At the base of the beak are the external nostrils, overhung by a bare patch of swollen skin, the *cere*. The eyes lie behind the cere, each provided with upper and lower eyelids and a transparent nictitating membrane. Behind and below the eyes are the two openings of the ears, each of which leads into a short tube ending in the tympanic membrane. There are no teeth either in the lower or in the upper jaw. *Internal nostrils* are present.

The trunk bears a pair of *wings* and a pair of legs. The *cloacal aperture* is at its hind end on the lower surface. Projecting behind the cloacal aperture is the *tail*.

The feathers are of three kinds: large *quill* feathers on the wings and tail which are used for flight; *contour* feathers, forming a covering for

Fig. 1.25 A down feather (top) and a filoplume

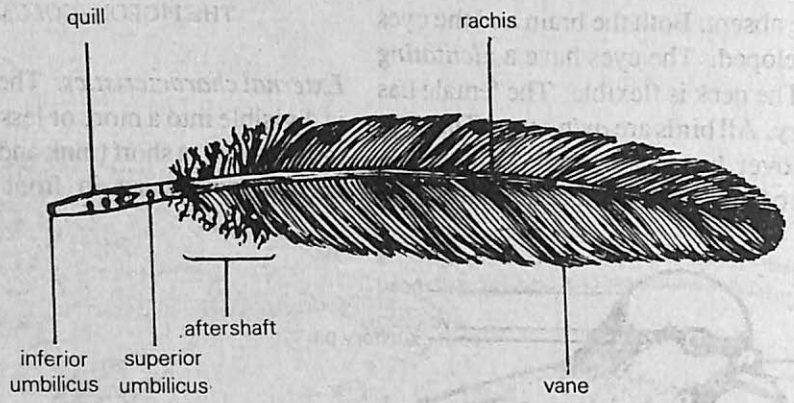


Fig. 1.26 A wing feather

the body, and *filoplumes*, lying between the contour feathers.

Activity 20: *Name two flightless birds and write a short note on their external features.*

Activity 21: *Collect feathers of different birds and paste them in your album.*

Activity 22: *Classify birds as seed eating, omnivorous or predatory birds. Give five examples for each.*

Class Mammalia

General characteristics: The word *mammal* comes from the Greek word *mamma* which means breast. In this class the young ones are nourished on the mother's milk. All the mammals possess hair on their body. They are warm-blooded. The skin has sweat glands for excretion and regulation of body temperature.

The heart is four-chambered. The red blood corpuscles are non-nucleated. The brain is highly developed. The teeth are embedded in sockets. The majority of mammals have two sets of teeth called *milk teeth* and *permanent teeth.* The coelom is divisible into two parts by a transverse partition called the *diaphragm.* The testes often descend into *scrotal sacs.* The males have a copulatory organ called the *penis.* The anus and urinogenital apertures are separate. The body is covered by epidermal hair. Respiration is only through the lungs. There are two pairs of *pentadactyle limbs* differently modified in different groups. The digits have nails. There is an external ear or *pinna* on either side of the head.

With the exception of a few primitive forms, mammals are viviparous. They have a device for nourishing the young embryo within the body of the mother.

Activity 23: *Classify mammals as herbivorous, carnivorous and insectivorous mammals and give two examples for each.*

THE RABBIT *(ORYCTOLAGUS CUNICULUS)*

Oryctolagus cuniculus is the common rabbit which belongs to the phylum Chordata, sub-phylum vertebrata and class Mammalia. Rabbits always live in groups and hence are gregarious in habit.

Structure: The body is divisible into the head, the trunk and the tail. It is covered with hair. A distinct neck connects the head with the trunk.

The head: Upper and lower lips are present. A *cleft* exposing the teeth appears in the upper lip and continues up to the *external nostrils*. The eyes are present laterally, each having upper and

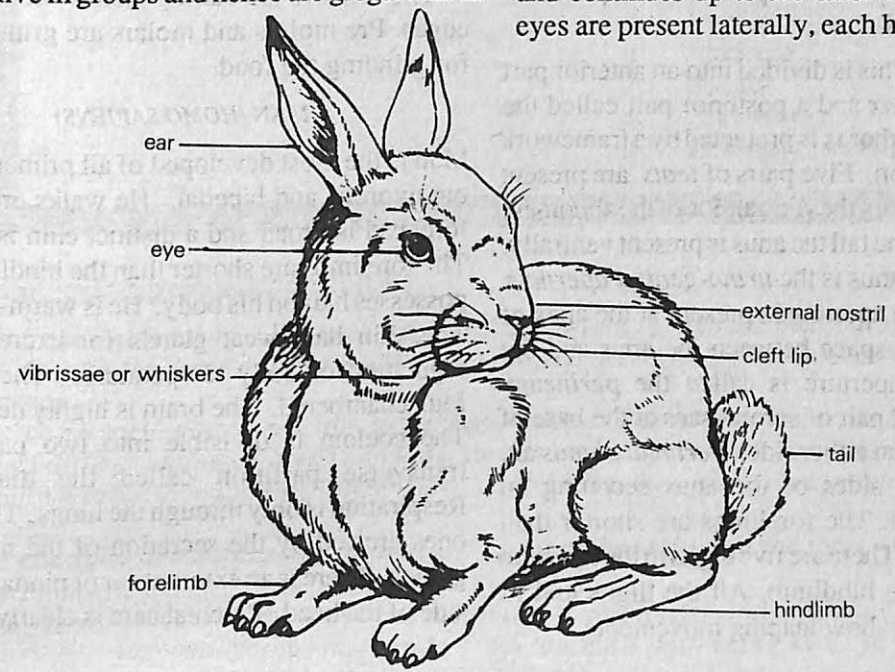


Fig. 1.27 The rabbit (Oryctolagus cuniculus)

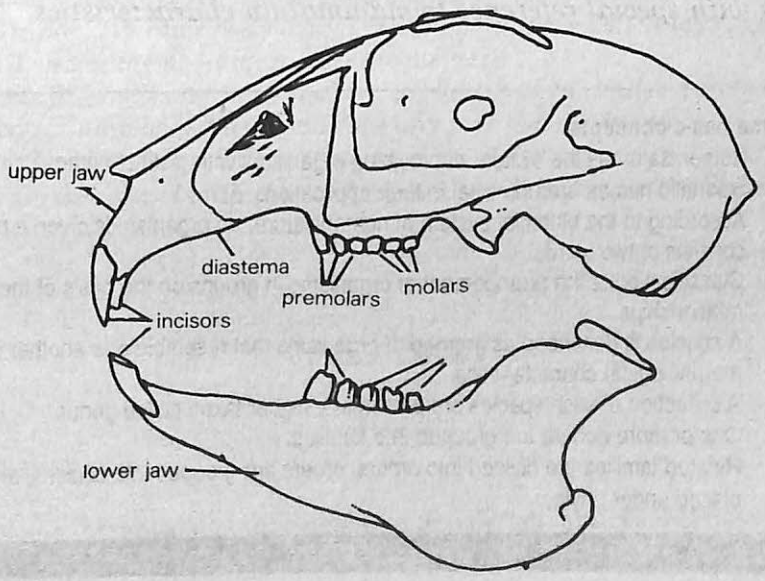


Fig. 1.28 Dentition in the rabbit

lower *eyelids*. Eyelashes are present. A *nictitating membrane* is present and it can be partly drawn over the eye. Stiff hairs forming the whiskers or *vibrissae* are present near the external nostrils. They are sensory in function. A pair of large *external ears* or *pinna* are present in the posterior part of the head.

The trunk: This is divided into an anterior part called the *thorax* and a posterior part called the *abdomen*. The thorax is protected by a framework of bony skeleton. Five pairs of *teats* are present in adult females on the ventral side of the abdomen. At the base of the tail the anus is present ventrally. Ventral to the anus is the *urino-genital aperture*. In the male the aperture is present at the apex of the penis. The space between the anus and the urino-genital aperture is called the *perineum*. The male has a pair of scrotal sacs at the base of the penis, one on either side. *Perineal glands* are present at the sides of the anus secreting an odourless fluid. The forelimbs are shorter than the hindlimbs. There are five digits in the forelimb and four in the hindlimb. All the digits end in claws. Rabbits show leaping movements.

Dentition: The dental formula is

$$I\ \frac{2}{1}\ C\ \frac{0}{0}\ PM\ \frac{3}{2}\ M\frac{3}{3}$$

Cannines are absent. The space between the incisors and premolars is called the *diastema*.

The *incisors* are cutting teeth with chisel-like edges. Pre-molars and molars are grinders used for grinding the food.

MAN *(HOMO SAPIENS)*

Man is the most developed of all primates. He is omnivorous and bipedal. He walks erect. The forehead is broad and a distinct chin is present. The forelimbs are shorter than the hindlimbs. He possesses hair on his body. He is warm-blooded. The skin has sweat glands for excretion and regulation of body temperature. The heart is four-chambered. The brain is highly developed. The coelom is divisible into two parts by a transverse partition called the diaphragm. Respiration is only through the lungs. The young ones are fed by the secretion of the mammary glands. There is an external ear or pinna on either side of the head. Parental care is clearly evident.

Activity 24: *Observe a preserved rat or rabbit and identify the external features with special reference to mammalian characteristics.*

Some basic concepts

1. Nomenclature is the system of providing organisms with distinct names.
2. Scientific names are universal in their application.
3. According to the binomial system of nomenclature, an organism is given a name that consists of two words.
4. Classification is the arrangement of organisms in groups on the basis of their relationships.
5. A species is described as a group of organisms that resemble one another in all essential morphological characteristics.
6. A collection of such species are placed in a higher taxon called genus.
7. One or more genera are grouped into families.
8. Related families are divided into orders, orders are grouped into classes, and classes are placed under phyla.

Major animal groups

Sub-kingdom : Protozoa

Phylum 1 Protozoa

Sub-kingdom : Metazoa

Phylum

1. Porifera
2. Coelenterata
3. Platyhelminthes
4. Nemathelminthes
5. Annelida
6. Arthropoda
7. Mollusca
8. Echinodermata
9. Chordata (vertebrata)

Some suggested projects / activities

1. *Cut off the antennae of a live cockroach and put it in a cardboard box containing a few rice particles. In the same box put another cockroach with its antennae intact. Observe their reactions.*
2. *Observe an earthworm's reaction to light and touch. Record your observations.*
3. *Collect different kinds of beetles, insects, worms, etc. and prepare a vivarium.*
4. *Prepare a table showing the different ways in which fishes, birds and mammals are useful to man.*
5. *Give examples of the following animals. You may like to do it in the form of a quiz programme.*
   a. one aquatic mammal. b. one flying mammal. c. one burrowing mammal. d. the largest mammal. e. two omnivorous mammals. f. two animals with spiny skin. g. two chordates with shells. h. two animals with streamlined bodies. i. two hermaphrodite animals. j. ten vertebrates which live in water. k. five insects which are useful man. l. two animals having minute pores in their body walls. m. two mammals which lay eggs.
6. *Prepare a skit on the theme 'protozoa versus metazoa'.*
7. *Collect pictures of various animals and try to classify them under different phyla. Refer to Natural Science Encyclopaedias if you face any problems doing this.*
8. *Observe a garden lizard and note its crest and hard dermal scales. Compare the external features of a garden lizard with that of a house lizard. Tabulate the differences.*

REVISION

I. Fill in the blanks.

1. The system of providing organisms with appropriate and distinct names is called ..... .

2. ..... is called the Father of Classification.
3. In the ..... system of nomenclature an organism is given a name of two words.
4. The first word of a scientific name is the ..... and the second word of the name is the ..... .
5. Nutritionally protozoans may be ..... or plant-like. The plant-like method of feeding is described as ..... .
6. They show ..... symmetry.
7. The suckers in the tapeworm are meant for ..... to the host.
8. The head of a cockroach has a pair of ..... eyes.
9. The abdomen and ..... bear lateral pores called ..... .
10. Molluscs rank only second to ..... in the number of species.
11. Aquatic respiration takes place through ..... or ..... .
12. The *Pila globosa* has a rasping organ called the ..... .
13. Amphibians have a moist, ... skin and a heart with only ..... chambers.
14. Behind each eye, the frog has a circular patch of stretched skin called the ..... membrane.
15. All mammals are ..... - blooded.
16. Incisors are teeth used for ..... .

II. Choose the correct answers.

1. Which of the following characteristics describe the amoeba's ever-changing shape? single-celled; invisible to the naked eye; found mainly on land and dry places; opaque body; digests food inside the food vacuole; sexual reproduction.
2. The hydra is a coelenterate because it has
   i. double layers. ii. a single layer. iii. a acoelomate nature.
3. Coelenterates are
   i. terrestrial. ii. arboreal. iii. aquatic.
4. The body of the hydra is
   i. cylindrical. ii. shapeless iii. spherical.
5. Digestion in the hydra is
   i. intracellular. ii. both intracellular and extracellular. iii. extracellular.
6. a. Nemathelminthes are
   i. bilaterally symmetrical. ii. asymmetrical.

   b. In nemathelminthes, a coelom is
   i. partially present. ii. absent.

c. The sexes are
i. separate. ii. non-differentiated.

7. Ascaris is a
i. parasite. ii. partial parasite.

8. Ascaris finds its way to its human host through
i. the air. ii. contaminated food.

III. Answer the following questions:

1. List the nutritional and reproductive features of protozoans.
2. Explain how the vital functions are carried out in the amoeba.
3. What are the general characteristics of platyhelminthes?
4. Describe the habit and habitat of the liver fluke.
5. What are annelids? In what ways are they different from nemathelminthes?
6. Make a list of the general characteristics of annelids.
7. In what distinct ways are arthropods different from annelids?
8. Describe the external features of *Pila globosa.*
9. Describe the habit and habitat of the sea star.
10. Describe the spinal nerve cord and the brain in chordates.
11. What are the chief characteristics of amphibians?
12. Describe, with the aid of a sketch, the features of a frog's head and trunk. What are the distinguishing features of reptiles?
13. Describe, with the aid of a sketch, the external features of the garden lizard.
14. What are the distinguishing features of Aves?
15. In what ways are mammals distinct from the other phyla?

IV. Mark true or false.

1. Playhelminthes are triploblastic animals, showing bilateral symmetry.
2. Suckers are muscular cups used for attachment to the host.
3. All annelids have well-developed nervous systems.
4. All annelids are hermaphrodite.
5. Molluscs are amphibians.
6. The mouth of the *Pila globosa* lies to the left of the columella.
7. Echinoderms are exclusively marine.

8. Sea stars are herbivorous.
9. The sea star is "blind".
10. Chordates have gills arranged in a single sequence.
11. Respiration is through the gills.
12. Sharks have two sets of fins.
13. Wings are a modification of the forelimbs.
14. Birds are poikilothermal.
15. The nictitating membrane is located in the neck.

V. Write is the names given to

1. the gastrovascular cavity.
2. the special stringing cells in the tentacles.
3. the images produced on the compound eyes.
4. the system of branching tubes in the thorax and abdomen in mammals.
5. the act of casting off an exoskeleton.
6. the basal segment of the antenna.
7. the straight, long tube which is part of the mouth of the mosquito.

VI. Explain the following terms:

a. poikilotherm. b. hibernation. c. aestivation. d. habitat. e. sexual dimorphism.
f. exoskeleton. g. remiges. h. nictitating membrane.

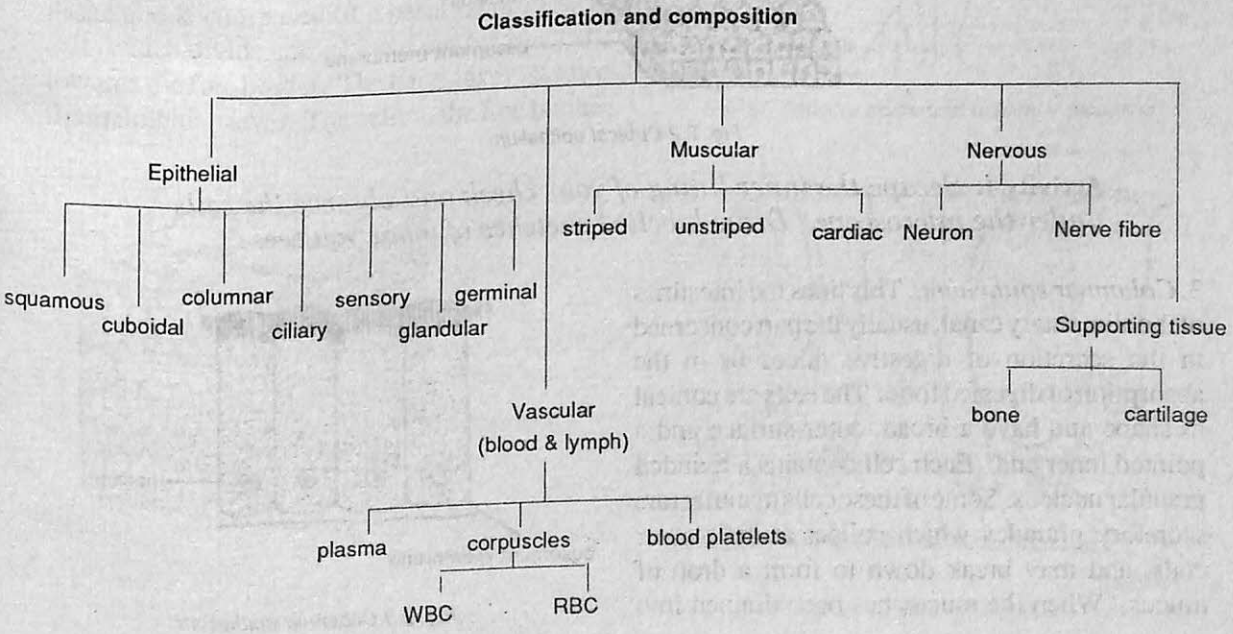
2. Organisation of animals

Types of animal tissues - blood plasma and its composition - muscular tissue - nervous tissue - bone tissue - skin - structure and functions - muscle - types - structure and functions - importance of actin and myosin - animal growth - variations - factors for growth.

The bodies of some microscopic organisms are composed of single cells. In these, different parts of the same cell perform different functions. All the cells in the body of a multicellular organism are not the same. They are specialised to perform special tasks within the body. These various cells specialised for a particular function are called tissues. In all organisms, organisation and division of labour among cells is a major feature.

2.1 Types of animal tissues and their functions

The bodies of animals are composed of several distinct tissues. These may be classified as follows.



2.2 Major animal tissues

EPITHELIAL TISSUE

An epithelial tissue covers a surface or lines a cavity in the body. It always has a free border or a surface which is not in contact with other cells. The inner side of the epithelial cells is always in contact with other cells and is separated from them by a delicate basement membrane.

There are two main types of epithelial tissues —*simple epithelium* and *stratified epithelium.* In the former, the cells are arranged in a single layer, while in the latter the cells are many-layered in thickness.

1. *Squamous epithelium:* The cells are flattened and pentagonal in shape. They are closely fitted—edge to edge. Each cell has a distinct nucleus in the centre. It is protective in function and superficial cells can be easily detached from the basement membrane and are replaced by other cells.

2. *Cubical epithelium:* The cells are cubical in shape and may have a clear or a granular cytoplasm. The nucleus is large and oval in shape and lines the ducts of various glands as in the bile-duct of the liver.

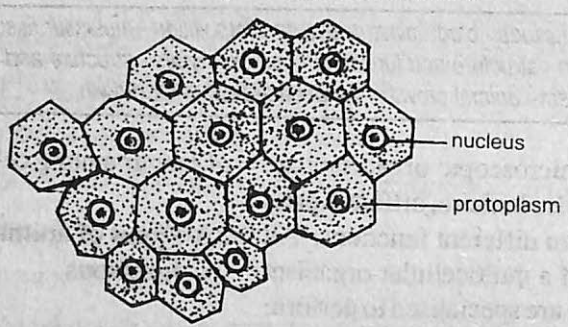


Fig. 2.1 Squamous epithelium

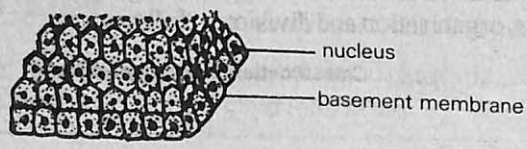


Fig. 2.2 Cubical epithelium

Activity 1: *Scrape the inner lining of your cheek and observe the cells under the microscope. Draw labelled sketches of what you see.*

3. *Columnar epithelium;* This lines the intestines of the alimentary canal, usually the part concerned in the secretion of digestive juices or in the absorption of digested food. The cells are conical in shape and have a broad, outer surface and a pointed inner end. Each cell contains a rounded granular nucleus. Some of these cells manufacture secretory granules which collect at their outer ends, and may break down to form a drop of mucus. When the mucus has been drained into

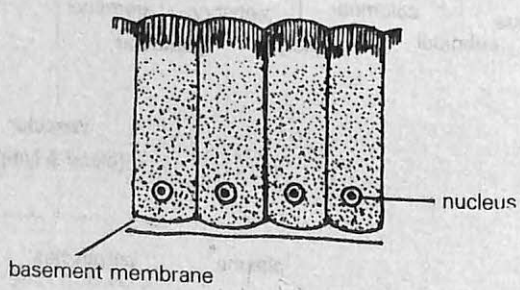


Fig. 2.3 Columnar epithelium

the cavity of the digestive tract, an empty space may be visible instead, and such cells are known as the *goblet cells.*

4. *Ciliated epithelium:* The cells are columnar in shape and their broad, free surface is covered over by a large number of fine processes of protoplasm, called *cilia.* The cilia by their lashing movements maintain a slow current of liquid over them. The lashing is more active in one direction. It lines the buccal cavity in the frog, and the bronchi in the rabbit.

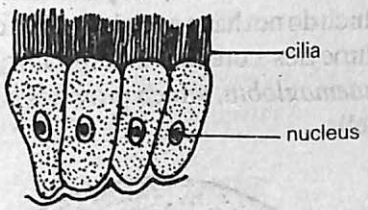


Fig. 2.4 Ciliated epithelium

5. *Striated epithelium:* The cells are columnar in shape and the free border of the cells is characterised by regular vertical striations which are final canals, and facilitate the process of absorption.

6. *Stratified epithelium:* This is a compound tissue and is composed of a basal layer of large cells which divide actively and cut off new cells towards the free border. The basal layer is called the malpighian layer. The cells at the free border, on the other hand, are removed constantly because their protoplasm becomes cornified and dies. This tissue is found in the skin of mammals and the conjunctiva of the eye.

7. *Sensory epithelium;* Some of the epithelial cells are modified to pick up stimulations and they form sense organs. Thus the olfactory epithelium contains sense organs of smell.

8. *Glandular epithelium:* Some epithelial cells produce substances that are useful to the body and thus they are secretory in function. The

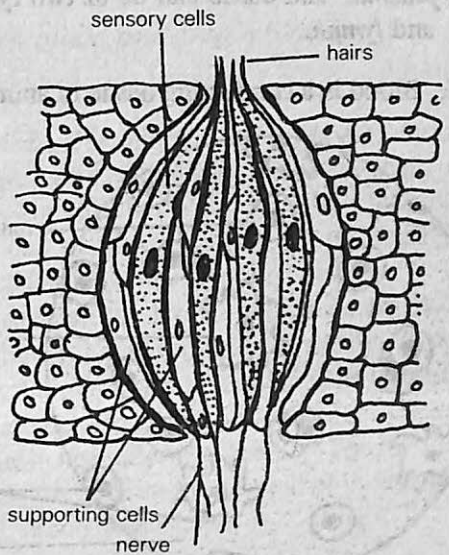


Fig. 2.6 Sensory epithelium (olfactory receptors)

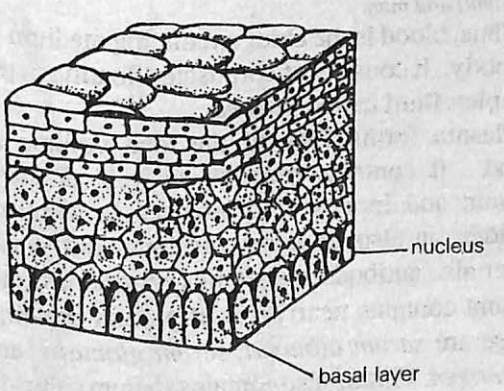


Fig. 2.5 Stratified epithelium

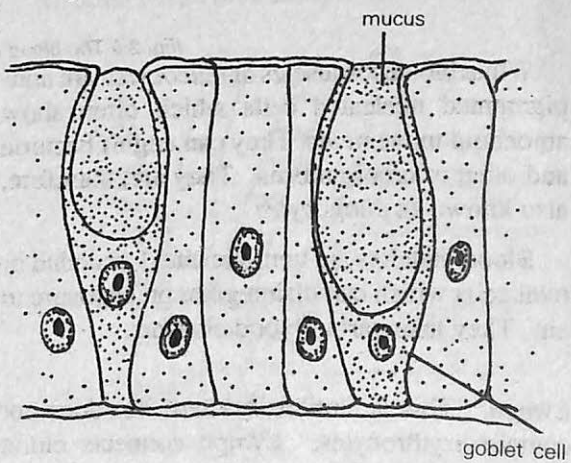


Fig. 2.7 Glandular epithelium

glands maybe unicellular, tubular or sac-like. Gastric glands in the stomach and salivary glands are examples.

9. *Germinal epithelium:* The epithelium of the sex organs may be modified to produce sex cells. Thus the outer covering of the ovary produces ova and the epithelium of the minute tubes that form the testes produces sperms.

VASCULAR TISSUE

Vascular tissue is a fluid connective tissue. It is fluid because of the presence of a liquid matrix called *plasma*. The tissue can be of two types, *blood* and *lymph*.

Blood: Blood is a conducting tissue in animals. It consists of a fluid called plasma and three types of living cells. Plasma is a crystallo-colloid solution in which various types of inorganic and organic substances are dissolved. There is a special protein called *fibrinogen* which can give rise to protein fibres at the time of blood clotting. Thus fibres are present in the blood like in other connective tissue.

The living cells include *red blood corpuscles, white blood corpuscles* and *blood platelets*. Red blood corpuscles or erythrocytes are usually the most abundant. In man, they are like biconvex discs which do not have a nucleus. The cytoplasm of erythrocytes contains a respiratory pigment called *haemoglobin*, which provides colouration to the cells.

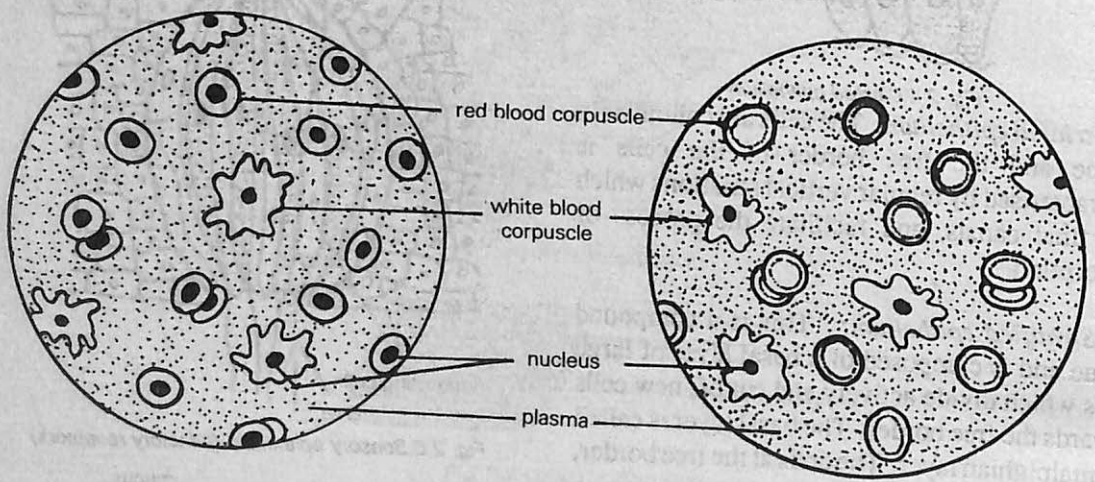


Fig. 2.8 The blood of a frog (left) and man

White blood corpuscles or *leucocytes* are non-pigmented nucleated cells which often show amoeboid movements. They can engulf bacteria and other microorganisms. They are, therefore, also known as *phagocytes*.

Blood platelets are non-nucleated, rounded or oval cells which can disintegrate on exposure to air. They take part in blood clotting.

Lymph: This is similar to blood but does not contain erythrocytes. Lymph connects blood with the cells of the body.

Thus, blood is the chief circulating medium in the body. It consists of corpuscles floating in the complex fluid called *plasma*.

Plasma forms 55% of the total volume of blood. It contains proteins as well as many organic and inorganic substances in solution. Besides, it also contains nutritive and waste materials, antibodies enzymes, hormones, etc. Plasma contains nearly 7% of plasma proteins. These are *serum albumin, serum globulin* and *fibrinogen*. Plasma also contains sodium chloride, potassium, calcium, magnesium, iron, etc., as its *inorganic* constituents.

Composition of blood

Plasma 55%

Organic and inorganic constituents

1. plasma proteins
2. nutritive materials, waste materials
3. enzymes
4. hormones
5. antibodies
6. NaCl, Ca, Mg, Fe, I

Corpuscles 45%

- R.B.C. (transport of O_2 and Co_2)
- W.B.C. (police force of the body)
- platelets (clotting of of blood)

Activity 2: *Observe prepared slides of human blood and frog's blood. Note their cell structures.*

MUSCULAR TISSUE

Muscular tissues can undergo contraction and are, therefore, called *contractile* tissues. These tissues are arranged in groups called muscles. A muscle consists of a number of muscle fibres which are covered over by a connective tissue to form a compact mass. All the fibres of a muscle can contract simultaneously. The contractibility of a muscle fibre is due to special protoplasmic fibrils called *myofibrils*. The cytoplasm of the fibres is called *sarcoplasm*.

Muscle fibres are of three types — *unstriated, striated* and *cardiac*.

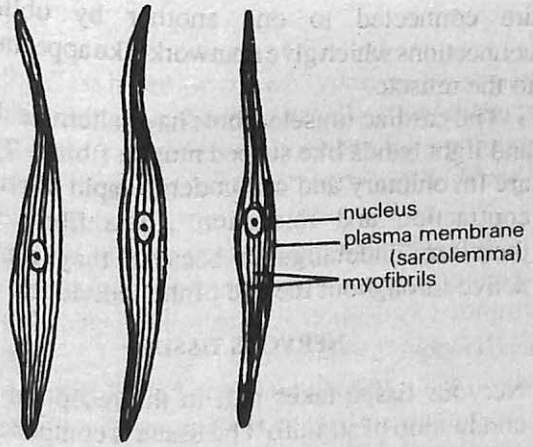


Fig. 2.9 Unstriped muscle

1. *Unstriped or smooth muscle fibres:* These are narrow, spindle-shaped and uninucleate cells which are surrounded by a plasma membrane. Each cell or fibre contains a large number of longitudinally running myofibrils.

Unstriated or smooth muscle fibres undergo slow but prolonged contractions. They do not get easily fatigued. Except in the case of molluscs they are not directly under the will of the animal and are hence called involuntary. The involuntary muscle fibres occur in the wall of the alimentary canal, blood vessels, etc.

2. *Striated or striped muscle fibres* are long

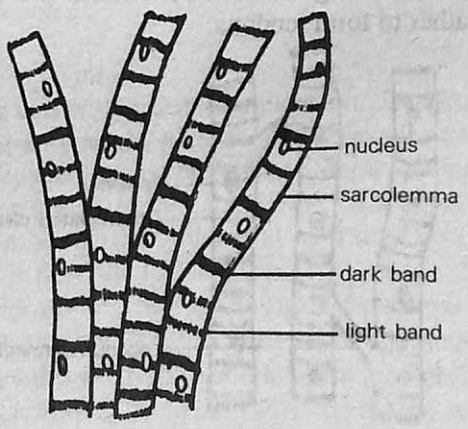


Fig. 2.10 Striped muscle

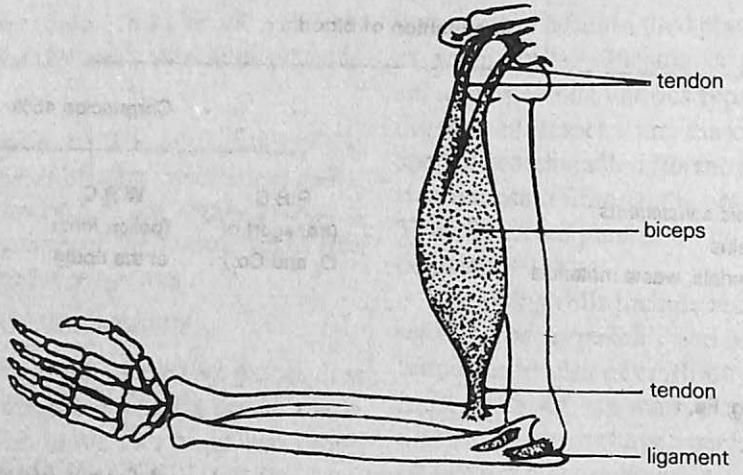


Fig. 2.11 Muscles, tendons and ligaments

fibres which possess numerous elongated nuclei. The fibres are covered over by an elastic covering called the *sarcolemma*. Internally they contain a number of longitudinally running *myofibrils*. The myofibrils have alternate dark-light bands. These bands provide transverse striations to the muscle fibres. In the middle of each dark band there is a narrow, light zone while a narrow, dark zone is present in the middle of a light band.

Striped muscle fibres are numerous and can form upto 50 per cent of the body. They occur in the body wall and are attached to all types of bones which are capable of movement. Hence they are also known as *skeletal muscle fibres*.

The muscles are attached to the bone through their covering seaths. Sometimes the sheaths gather to form tendons.

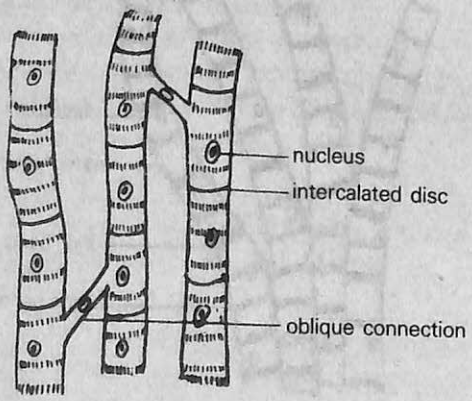


Fig. 2.12 Cardiac muscle fibres

The striated muscle fibres contract under orders from the will or conscious brain. They are, therefore, also called *voluntary* muscle fibres. During their contractions the dark bands shorten and become broader. Contraction is very quick but the contracted muscle fibres get fatigued very early. The muscles, therefore, cannot remain in the contracted form for a long period.

3. *Cardiac muscle fibres:* These fibres occur in the wall of the heart and are intermediate in structure between striped and unstriped fibres. A cardiac muscle fibre consists of a number of uninucleate cells placed end to end. The individual cells can be recognised by the presence of dark and thick intercalated discs. The adjacent fibres are connected to one another by oblique connections which give a network-like appearance to the muscle.

The cardiac muscle fibres have alternate dark and light bands like striped muscle fibres. They are involuntary and can undergo rapid alternate contraction and relaxation. The fibres are, therefore, indefatigable because they remain active throughout the life of the individual.

NERVOUS TISSUE

Nervous tissue takes part in the reception and conduction of stimuli. The tissue is composed of nerve cells which are surrounded by insulating

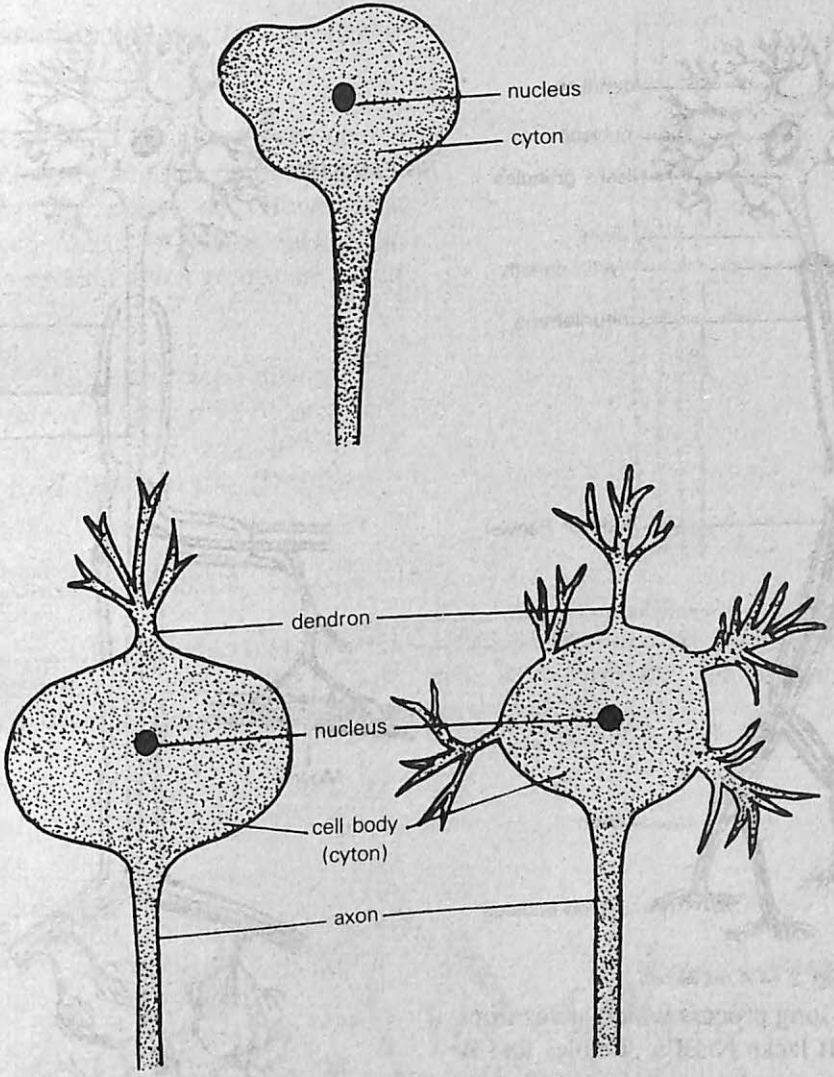


Fig. 2.13 Types of nerve cells

cells. The latter are of two types, *neuroglia* and *Schwann's cells*. Neuroglia cells are of different types which form a packing material around the body of the nerve cells. Schwann's cells occur in tubular sheaths around the nerve fibres.

Nerve cells or neurons are differentiated into three parts—the *cyton* or cell body, *dendrons* and *axons*. The cyton or cell body has a limiting membrane which surrounds a specialised cytoplasm called the *neuroplasm*. The latter contains a large nucleus, numerous granules of RNA called *Nissl's granules* and fine threads called *neurofibrils*.

The cell body bears a single axon. Dendrons may or may not be present. A nerve cell which has only the axon is said to be *unipolar*. When a dendron is also present, it is described as *bipolar*. If a number of dendrons occur on a single nerve cell, it is described as *multipolar*.

Dendrons are short, protoplasmic outgrowths of the cell body. They contain Nissl's granules. Each dendron is usually divided into several fine branches called *dendrites*. The dendrons take part in conveying impulses to the cell body.

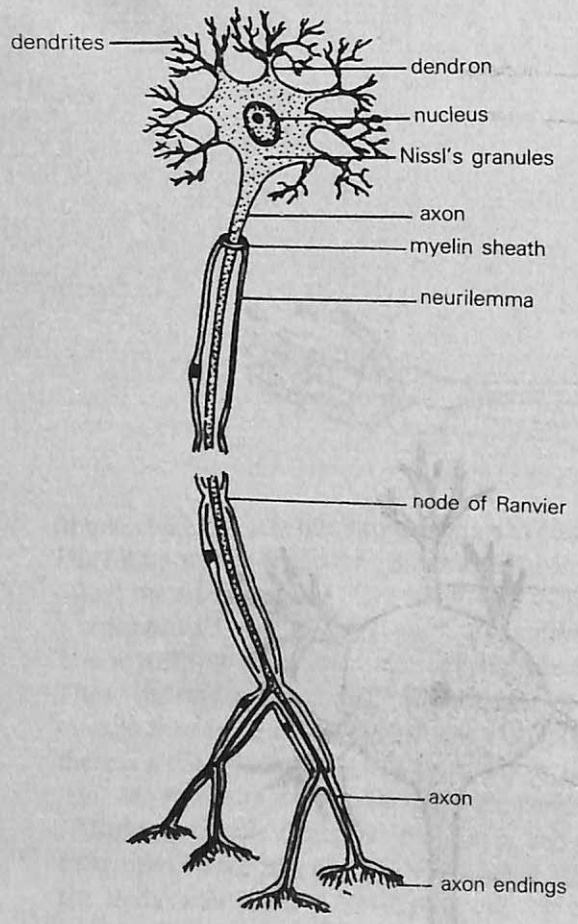


Fig. 2.14 A nerve cell

The axon is a long process which arises from the cell body. It lacks Nissl's granules and is meant for carrying impulses away from the cyton. It can, however, receive sensations.

The axons are usually covered over by one or two sheaths and are called nerve fibres. The nerve fibres are aggregated to produce nerves.

Nerve fibres are of two types: medulated and non-medulated.

1. *Medullated nerve fibres:* These are white in colour. Each medullated nerve fibre contains an axon or neuraxis which is covered over by two sheaths, the *neurilemma* and the *medullary* sheath. The medullary sheath is the inner of the two. It consists of fatty material. The medullary

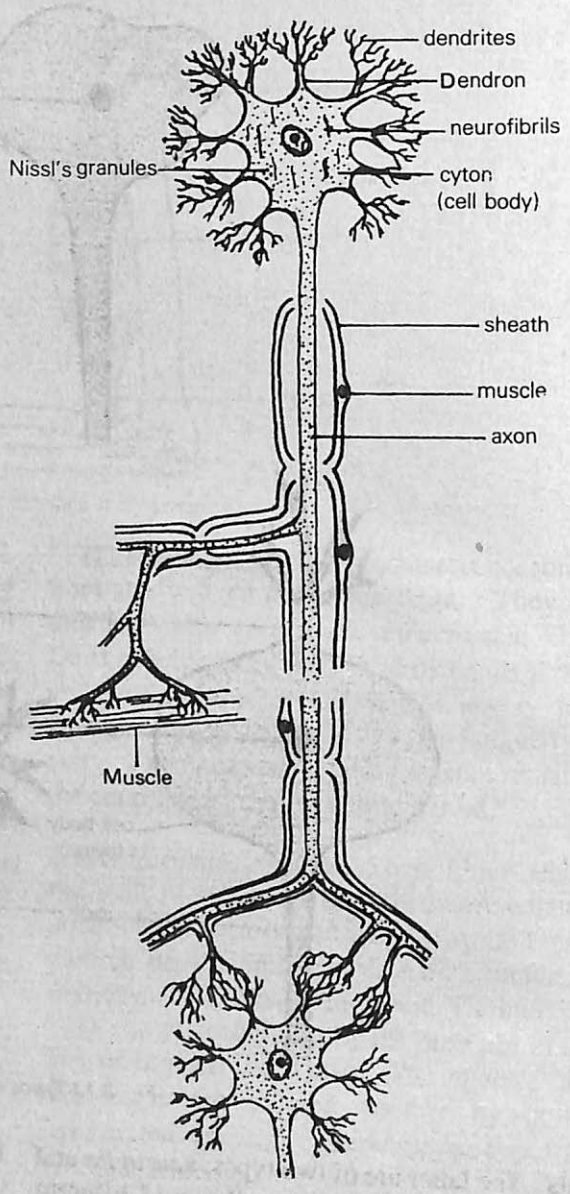


Fig. 2.15 Medullated nerve fibre (lateral section)

sheath is thin or absent at places called the *nodes of Ranvier*. The area between two nodes is called an internode. The neurilemma is composed of Schwann's cells. They are tubular and uninucleate. Usually one cell is present on the area of an internode.

2. *Non-medullated nerve fibres* are grey in colour. A non-medullated nerve fibre consists of an axon

surrounded by neurilemma only. Nodes of Ranvier are therefore not found on them.

3. *Ganglia:* Nerve cells are mostly restricted to the central nervous system (the brain and spinal cord). Only their fibres come out. However, at places nerve cells occur in groups outside the central nervous system. Such groups are called ganglia.

Activity 3: *Observe various animal tissue (prepared slides) and record the structure of each. Bring out the structural and functional differences in each.*

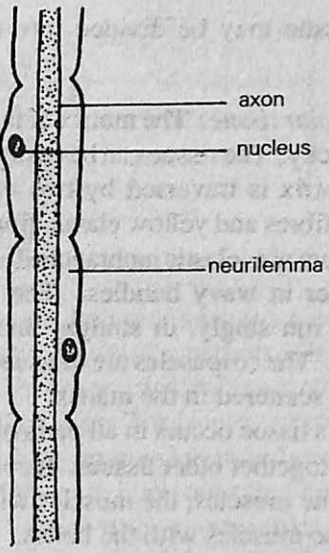


Fig. 2.16 Non-medullated nerve fibre (lateral section)

CONNECTIVE TISSUE

As the name indicates, this tissue serves to connect different organs with one another. The cells of this tissue are known as *corpuscles* and secrete a substance, the *matrix*. The secretion of these cells is so large that the cells themselves get embedded in it.

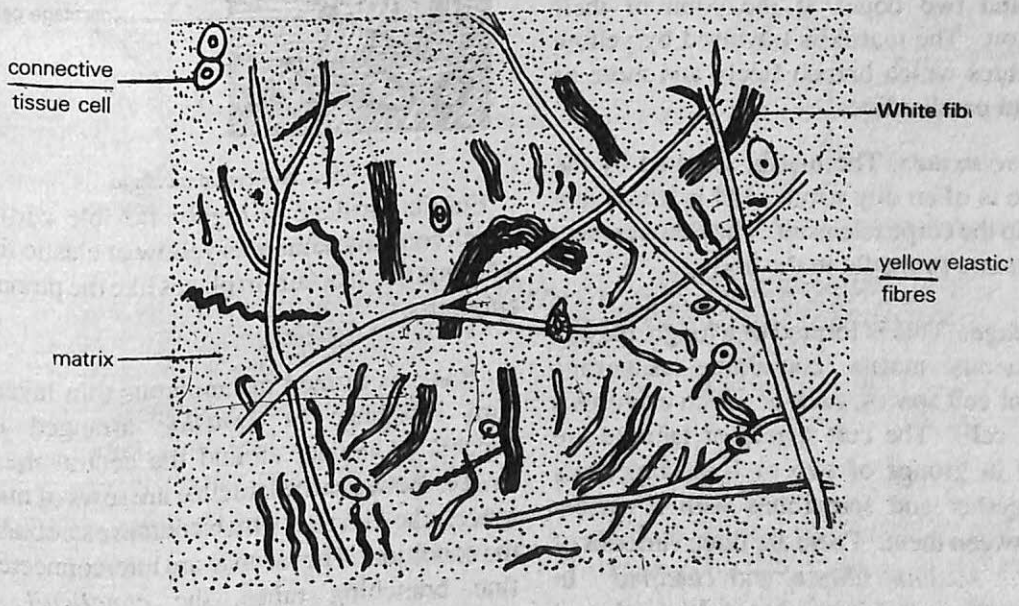


Fig. 2.17 Areolar tissue

The tissue may be divided into the following types:

1. *Areolar tissue:* The matrix of this tissue is soft and sticky. The tissue can be easily stretched and the matrix is traversed by two types of fibres, white fibres and yellow elastic fibres. The white fibres are non-elastic, unbranched and are grouped together in wavy bundles. The yellow elastic fibres run singly, in straight lines, and branch freely. The corpuscles are of usual shape and are found scattered in the matrix.

This tissue occurs in all parts of the body, and binds together other tissues. It connects the skin with the muscles, the muscles with one another and the muscles with the bones.

2. *White fibrous tissue:* This tissue forms tendons and muscle sheaths which connect the muscles to the bones. It is composed of white fibres which run parallel to one another in groups. The corpuscles are arranged in rows between them, along with a small quantity of fluid matrix.

3. *Yellow elastic tissue:* This forms the ligaments which bind two bones at the point of their articulation. The matrix is traversed by yellow elastic fibres which branch freely and more or less run in parallel lines.

4. *Adipose tissue:* The matrix secreted by the corpuscle is of an oily nature, and is stored in a vacuole in the corpuscle itself. The fibres are few and the tissue forms fat in the body.

5. *Cartilage:* This is formed of a tough, elastic, homogeneous matrix containing numerous cavities or cell spaces, each of which encloses a cartilage cell. The cell spaces or lacunae are arranged in groups of two or four sometimes close together and sometimes with a narrow space between them. There are three varieties of cartilage: *hyaline, fibrous* and *calcified.* In hyaline cartilage the matrix is tough, elastic and homogeneous, in fibrous elastic cartilage the gelatinous matrix is penetrated by a large number

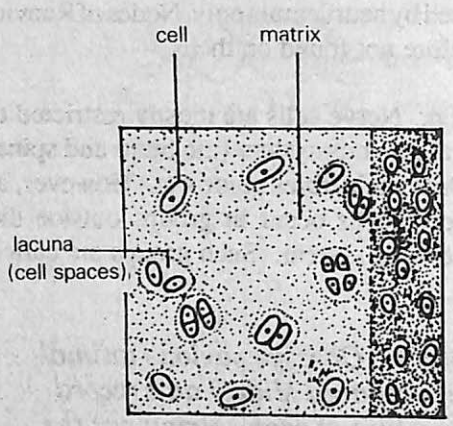


Fig. 2.18 Hyaline cartilage

of elastic fibres, and in the calcified cartilage the matrix is impregnated with calcium salts, and is therefore firm and brittle. The hyaline cartlage occurs in the trachea, ear and nose of mammals. The fibrous cartilage occurs in the extremities of the femur in the frog.

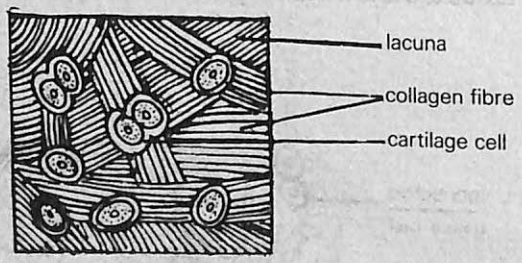


Fig. 2.19 Fibrous cartilage

Elastic cartilage is highly flexible cartilage which contains numerous yellow or elastic fibres in its matrix. It occurs in places like the pinna and epiglottis.

6. *Bone* is formed of numerous thin layers of hard substance or *lamellae* arranged in a concentric manner around the central marrow cavity. Between the lamellae are rows of minute spaces, the *lacunae*, which contain osteoblasts in the condition. The lacunae are interconnected by fine branching tubes, the *canaliculi.* The osteoblasts are interconnected by means of minute protoplasmic processes which pass out through the canaliculi. New lamellae are formed by the

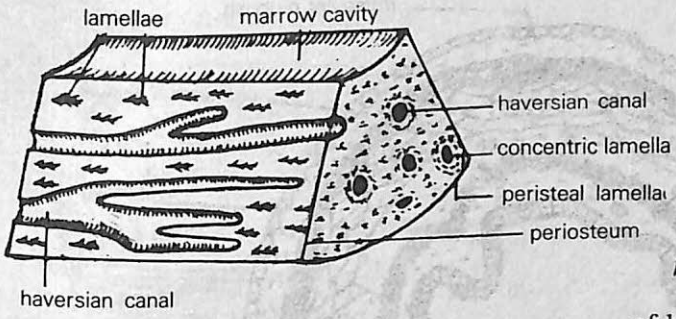


Fig. 2.20 A diagrammatic representation of a section of human bone

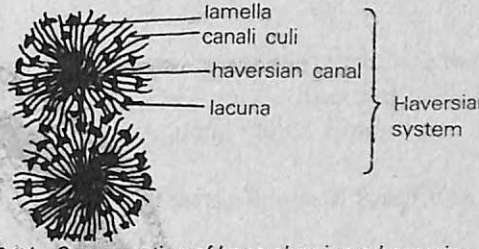


Fig 2.21 Cross section of bone showing a haversian system

activity of the osteoblasts. The marrow cavity contains bone marrow which is formed of *connective tissue, blood vessels* and *fat cells*. The bone is covered over on the outside by a thin membrane, the *periosteum*.

The body of the bone is formed of numerous *haversian systems*. In each such system there is a central canal, the *haversian* canal, which encloses a blood vessel. The haversian canals of the different systems are inter-connected by means of branches, and the bone thus has a complete vascular supply. The hard substance is laid down around each haversian canal in concentric rings known as the lamellae. The lacunae or spaces for the osteoblasts are arranged in rows between the lamellae, and they are interconnected by minute branching tubes—the canaliculi. The protoplasmic processes of the osteoblasts pass through them. The bone is covered over on the outside by a layer, the periosteum. The lamellae just underneath the periosteum are arranged parallel to the surface.

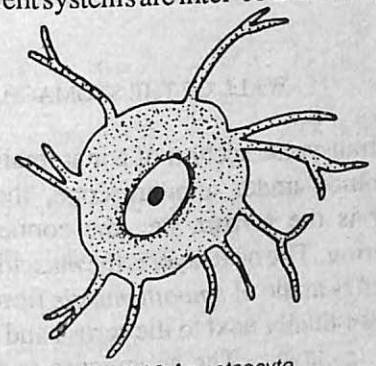


Fig. 2.22 An osteocyte.

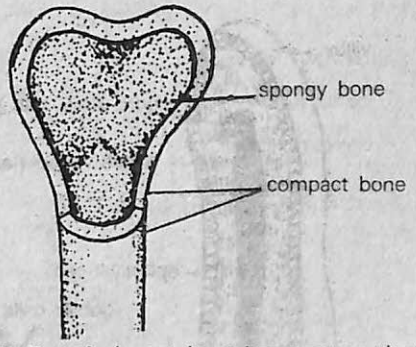


Fig. 2.23 Part of a human bone (transverse action)

Activity 4: *Obtain a large bone from the butcher. Saw it carefully through the head transversely and vertically. Try to identify the different parts.*

Remove pieces of tendon and lean meat (muscles) attached to the bone. Separate some of the fibres from each with mounted needles and examine under a microscope.

The compound tissues

SKIN

The skin forms the covering of the body and is made up of a group of compound tissues such as epithelial, muscular and connective tissues. The hair follicles are connected to the general malpighian layer by means of unstriped muscle fibres and the contraction of these muscles makes the hair erect.

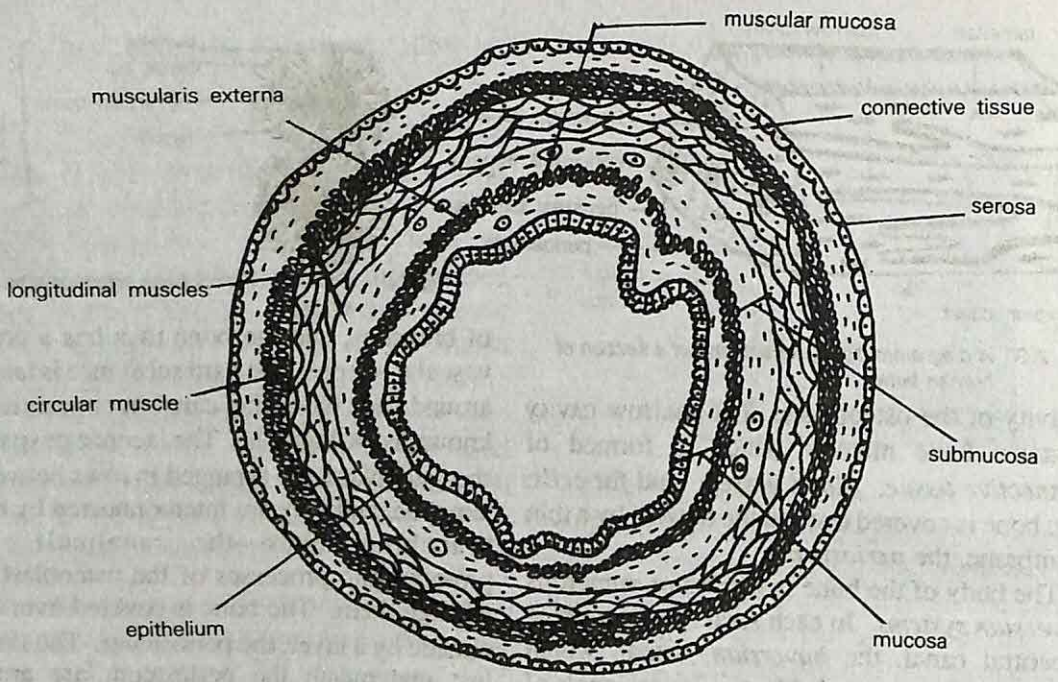


Fig. 2.24 A transverse section showing the arrangement of tissues in the stomach and the intestine

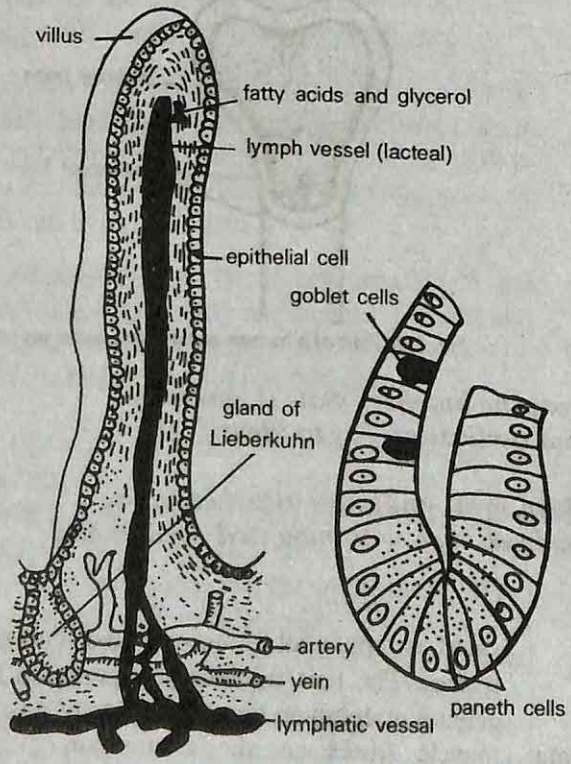


Fig. 2.25 Transverse section of intestine showing villus

WALL OF THE STOMACH

In a transverse section of a mammalian stomach examined under a microscope, the outermost layer is the *serosa*, i.e., the connective tissue covering. The next layer is the *muscularis externa* which is made of *smooth muscle* fibres, arranged longitudinally next to the serosa and the *circular muscle* layer. The submucosa is the adjacent layer, which has loose collagen fibres (connective tissue). The mucosa is the innermost region, forming the mucous membrane and is lined by a *simple columnar epithelium*.

The submucosa of the stomach is the dense connective tissue.

THE SMALL INTESTINE

The basic structure of the small intestine is similar to that of the stomach. However, the submucosa is folded to form finger-shaped Villi. Each villus is a projection lined by a single layer of simple

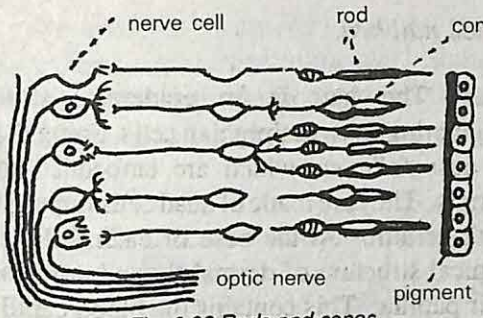


Fig. 2.26 Rods and cones

columnar epithelium which has absorbing cells and mucous cells known as *goblet cells*.

RETINA

In vertebrates two types of photoreceptors occur in the retina of eye. They are the *rods* and *cones*. The rods contain a pigment called *rhodopsin*.

2.3 Skin—outline of structure and functions

Almost every part of the body's external surface is covered with skin, and the few parts not covered have a covering membrane somewhat like the skin. Even the hair and the nails are outgrowths of the skin.

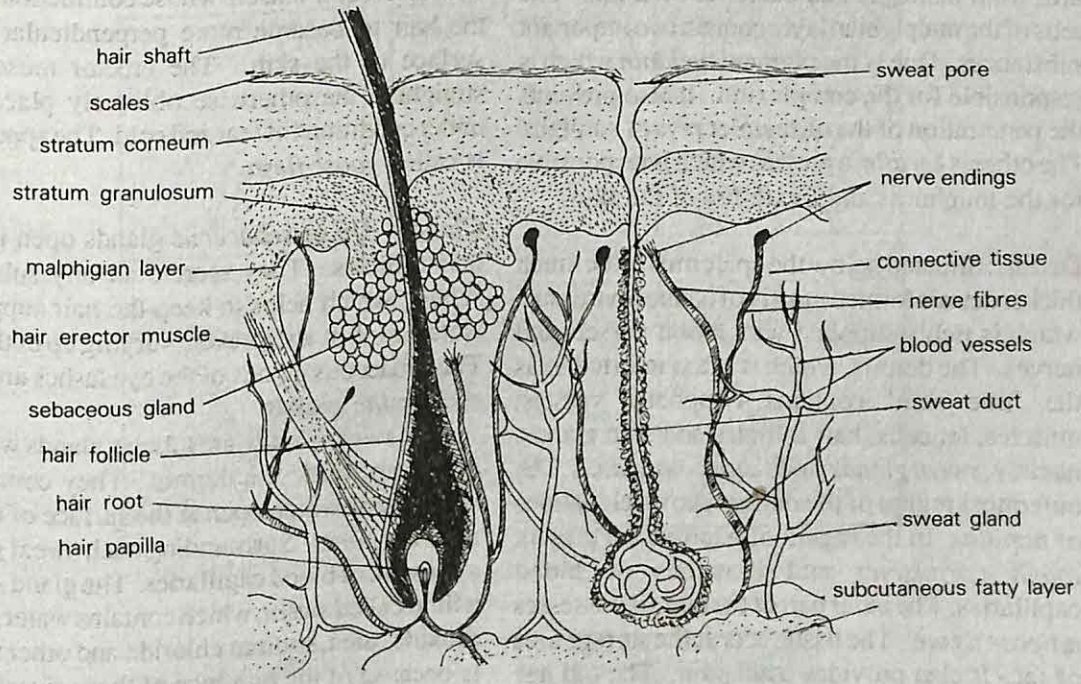


Fig. 2.27 Section of the human skin

Activity 5: *Observe a model of the human skin and identify its parts.*

STRUCTURE OF SKIN

The skin is composed of two chief layers — the outer skin, called the *epidermis*, and the inner skin, the *dermis*.

Epidermis: The outer layer or epidermis consists of three layers, an outermost *cornified layer*, or *stratum corneum*, a middle *granular layer*, or *stratum granulosum* and an innermost *pigmented layer*. This layer consists of a row of actively

dividing cells known as the *malpighian layer*. The cells of the malpighian layer divide constantly and produce new epidermal cells. As they divide, the older cells are pushed towards the surface, in the course of which they become progressively flattened and lose their cell-like nature. The surface of the epidermis consists of dead, flat, translucent and overlapping scales. These scales are often worn away and removed, and as this happens more cells are formed by the malpighian layer below. The cells of the granular layer are living but those of the cornified layer are dead. The cornified layer forms a tough, waterproof covering for the living cells below. It protects the skin from damages and bacterial invasion. The cells of the malpighian layer contain two important substances. One is the pigment *melanin* which is responsible for the complexion. It also prevents the penetration of the ultraviolet rays of sunlight. The other is *keratin*, a protein which is responsible for the toughness and flexibility of the skin.

Dermis: Situated below the epidermis is the much thicker dermis formed mostly of connective tissue, which is richly supplied with blood vessels and nerves. The dermis, which is often referred to as the 'true skin' contains lymphatic vessels, muscles, fat cells, hair follicles and skin glands, namely, *sweat glands* and *sebaceous glands*. The outermost region of the dermis shows elevations or *papillae*. In the region of papillae are present *touch corpuscles* and branches of blood capillaries. The inner part of the dermis possesses *adipose tissue*. The tissue acts as the storage area of fat. It also provides insulation. The old age wrinkling of skin and greater perception of cold are linked to reduction in this tissue.

ACCESSORY STRUCTURES *(APPENDAGES)*

The skin possesses a number of accessory structures. They are:

Nails: These are keratinised portions of skin which are formed at the tips of fingers and toes. A nail is produced by a special area commonly called *nail bed*.

Hair: The hair is an epidermal structure originating from malpighian cells, lining the pits or *hair follicles*, which are embedded in the dermis. They are made of dead cells impregnated with keratin. At the base of each follicle is a conical structure of dermal tissue known as the hair papilla. This contains the blood capillaries and nerves associated with the growth of hair. Each hair is made up of a *hair root* and *hair shaft*. The former is embedded in the skin while the latter projects outwards at an oblique angle to the surface of the skin. Each hair follicle is associated with an *erector muscle* whose contraction causes the hair to become more perpendicular to the surface of the skin. The erector muscle can straighten the otherwise obliquely placed hair under conditions of fear and cold. The appearance is called *goose flesh*.

Glands: Oil or *sebaceous* glands open into the hair follicles. They secrete an oily substance, *sebum*, which helps to keep the hair supple and waterproof. It also prevents drying up of the skin. The sebaceous glands of the eye lashes are called *meibomian glands*.

The *sweat glands* are tubular glands which lie coiled up inside the dermis. They continue as *sweat ducts* which open at the surface of the skin as *sweat pores*. Surrounding each sweat gland is a network of blood capillaries. The gland secretes a fluid called *sweat*, which contains water, carbon dioxide, urea, sodium chloride and other salts. It is because of the presence of these sweat glands that the skin is able to function as an excretory organ. The secretion of sweat helps in regulating body temperature.

Mammary and *ceruminous glands* are modified sweat glands. Mammary glands produce milk and ceruminous glands form *ear wax*.

Sense organs: There are various types of nerve endings scattered in the dermis. Some are sensitive to touch *(touch corpuscles)*, some to heat and

cold *(temperature corpuscles)* and others to pressure changes *(pressure corpuscles)*. Some of these corpuscles help the body to sense pain. Nerve fibres originating from the touch corpuscles of the skin connect them to the brain, so that the stimuli picked up by the sense organs may be transmitted to the brain where they are interpreted.

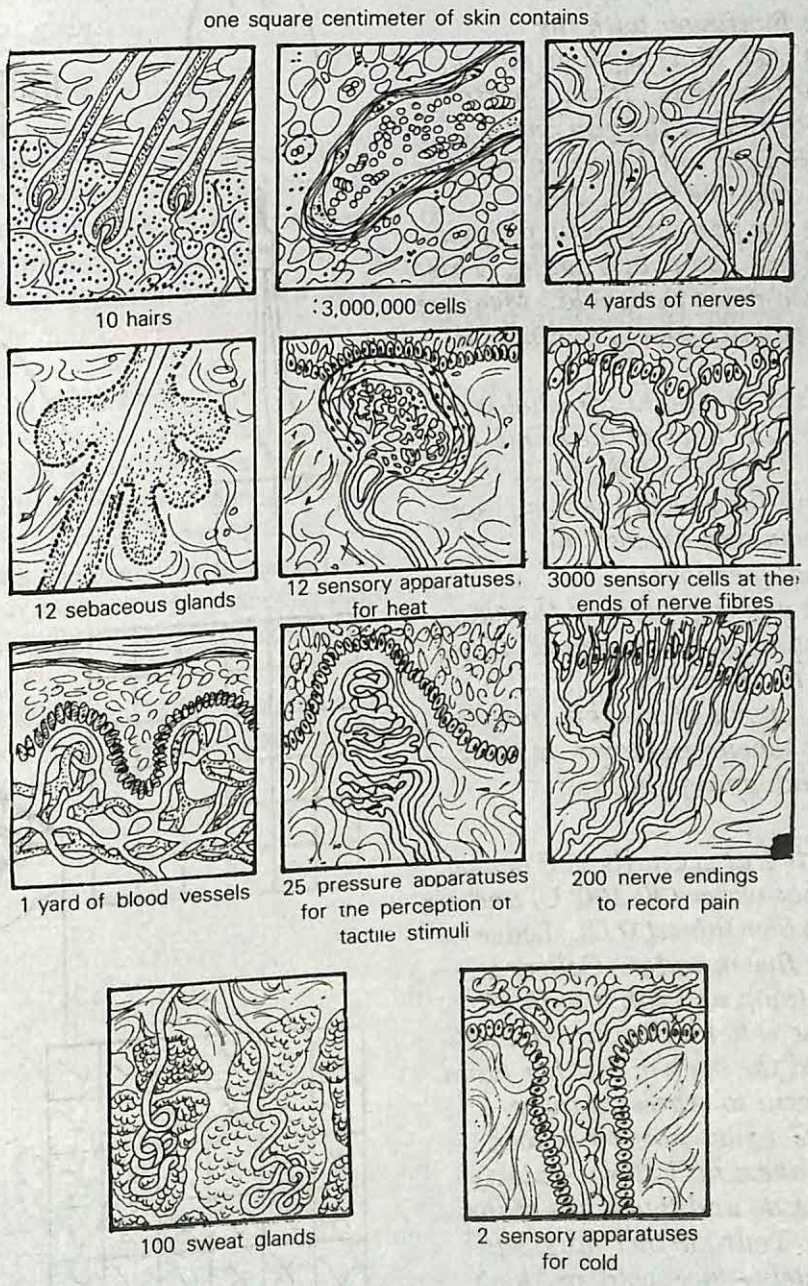
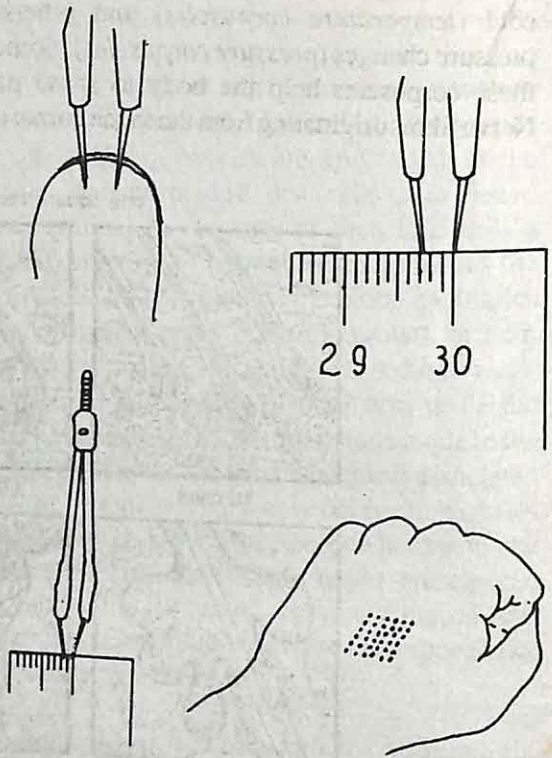


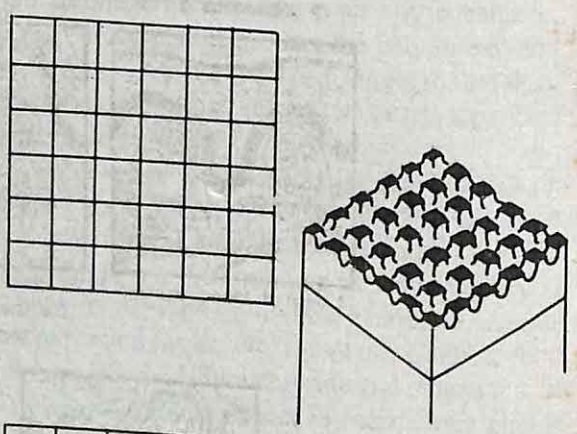
Fig. 2.28 Parts of the skin

Activity 6: *Work in pairs. Make your partner sit at the desk with his/her arm resing upwards on it. Take a pair of dividers and set them 2 mm apart. Touch the tip of your partners forefinger with the dividers. Ask him/her how many points he/she feels. If your partner says 'two', reduce the gap and try again. Repeat until your partner can feel only one point. Now increase the gap until your partner can just feel two points again. This is the 'two-point threshold. Measure the gap in millimetres and note it down.*

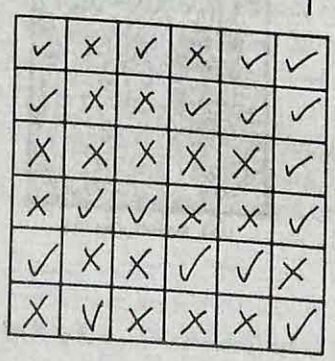
Find the two-point thresholds for the palm, the back of the hand, the forearm, the back of the neck, the cheek and the sole of the foot. Note them down and answer the following questions:

a. *Are touch receptors in the skin the same distance apart? If not, how do they vary?*
b. *Which parts of the skin have the most touch receptors? Is there any advantage in this?*





Activity 7: *Put six nails in a beaker of very hot water (90-100° C) and six in iced water (about 0°C). Leave them for five minutes. Collect a rubber stamp and ink it with 36 dots. Use it to mark your partner's palm and the back of his/her hand. Make a grid to represent these points. Get your partner to look away. Take a nail, dry it quickly with a tissue and touch one of the ink dots. Your partner must say immediately—'hot','cold' or 'don't know'. If the answer is correct, put a*



tick (✓) in the appropriate box in your grid. If wrong, put a cross (X). Put the nail back in its beaker. Take a fresh nail and repeat. Continue until the grids are filled. Think about the following questions.

a. Do all parts of the skin respond to heat loss or gain?

b. Does a spot on the skin which responds to heat loss also respond to heat gain?

FUNCTIONS OF THE SKIN

Judging from the numerous advertisements for soaps, lotions and creams, one might think the chief importance of the skin is its appearance. The skin serves the body not only as a covering but in so many other important ways that it can be actually called an organ.

Protection: The dead horny layer is tough, impervious and inert. It provides protection against entry of bacteria (which can enter only through hair follicles and sweat glands or where the skin has been broken), loss of water, and against frictional damage. The adipose tissue acts as a cushion and assists in protecting more delicate tissues under the skin from knocks and blows.

Oil from the sebaceous glands maintains the hair shaft in good condition by making it supple and less liable to break.

Both the sweat and the oil tend to dry on the surface of the skin, forming a film which becomes rancid and offensive. This film collects dirt.

Oil also makes the skin waterproof and destroys certain bacteria.

The skin gives protection from radiation. Cells below the epidermis produce a brown pigment in response to excessive exposure and this acts as a barrier to the sun's rays—hence the skin 'goes brown'. Fair-skinned people produce less of the pigment and are more likely to blister as a result of skin damage. Some of them produce the pigment only in small isolated patches in the skin and become 'freckled' when exposed to the sun.

Excretion: Though the chief organs concerned with the elimination of metabolic waste products are the kidneys, the skin through its sweat glands also helps in the process. Surrounding each sweat gland is a network of capillaries. As blood flows through these capillaries, the waste products

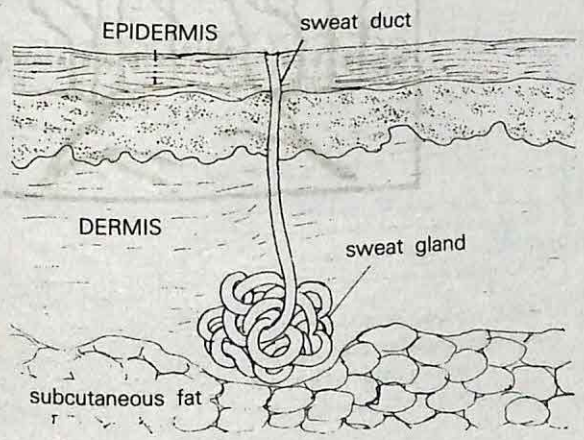


Fig. 2.29 A sweat gland

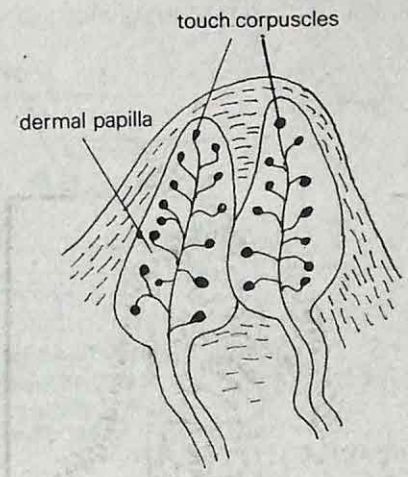


Fig. 2.30 Dermal papilla and touch corpuscles

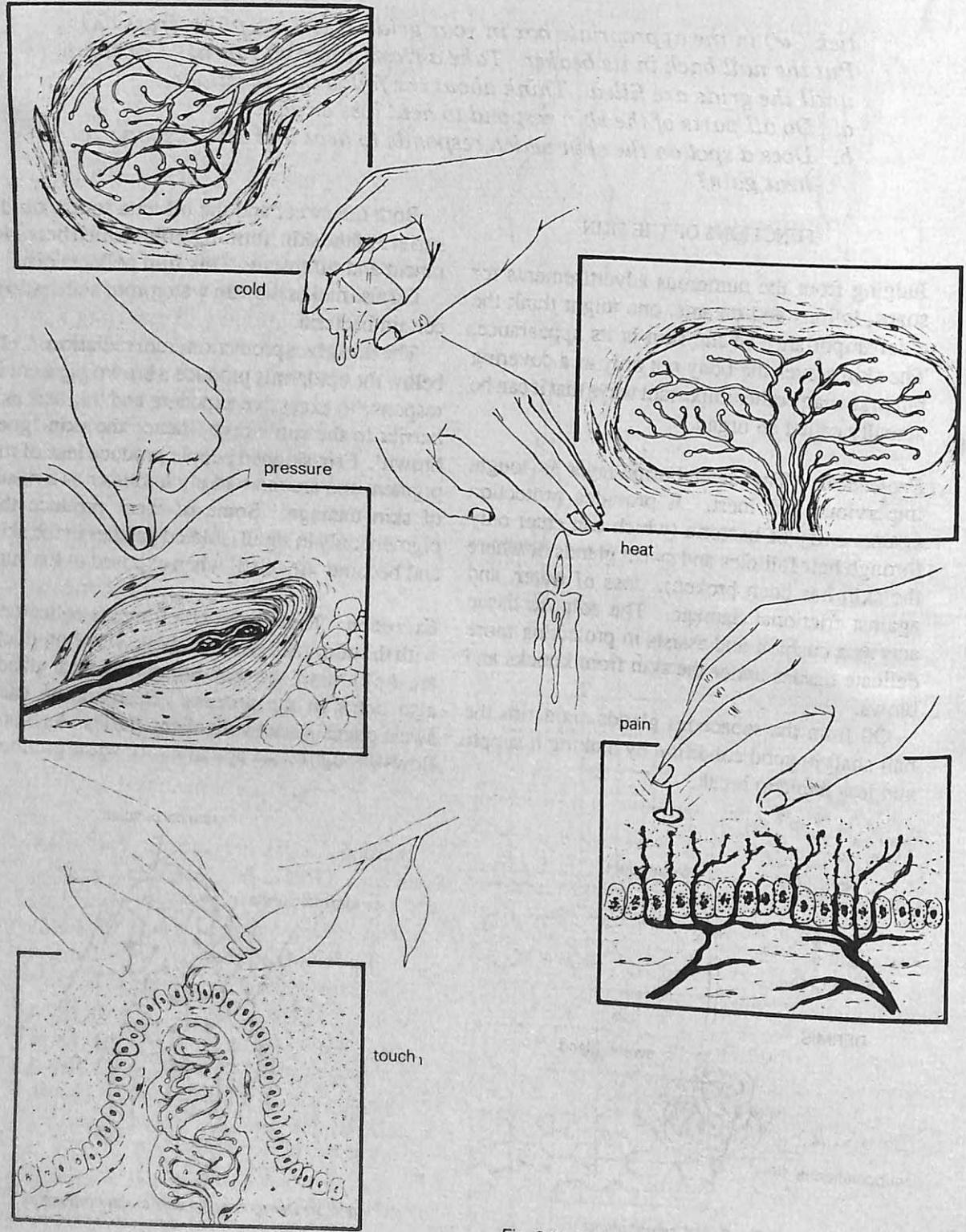


Fig. 2.31 Sensory nerve endings of the skin

such as water, small quantities of urea, mineral salts (mainly sodium chloride), other solids and carbon dioxide are absorbed by the sweat glands. These substances pass out through the ducts and the pores as *sweat.*

Sensory function: In man, the ability to respond to a stimulus depends upon the existence of specialised cells called *receptors.* These are cells which, when suitably stimulated, generate and release small amounts of electrical energy sufficient to trigger off nerve impulses in the nerve endings of sensory neurons associated with them. In some cases the receptor cells are distributed more or less throughout the tissue in which they are found. This is the case with the receptors for touch, pain, temperature in the skin, and for the pressure receptors in the muscles. A number of different types of receptors which are sensitive to touch have been identified in the skin. Some of these are stimulated by light contact and appear to be associated with hair follicles. Others appear to be stimulated only by pressure. There are two types of temperature-sensitive receptors in the skin. One type is most active at temperatures of about 30°C, the other is stimulated most effectively by temperatures of about 40°C. Special receptors (pain receptors) are known to exist in the skin which respond to excessive stimulation (mechanical, or heat or cold).

Thus, the numerous microscopic sense organs and nerve endings hidden in the skin make it an important sensory structure that picks up different stimuli of varying intensities and informs the brain of such changes in the environment. Such information is essential to the body, which must keep adjusting itself to its changing environment.

Production of vitamin D: When ultraviolet rays penetrate the skin they react with fatty substances called *sterols* in the dermis. These become converted into vitamin D. In this way a proportion of the nutritional requirement of this vitamin is made naturally by the body except in industrial areas where the ultraviolet light is filtered out by smoke in the atmosphere. The vitamin D is then absorbed into the blood, and is essential for the normal growth and development of the skeletal system. The skin also absorbs oils containing ergosterol rubbed on to it, and this can assist the production of vitamin D.

The skin as a heat-regulating organ: The skin helps man to maintain a constant body temperature. Mammals and birds, are *homoiothermic,* i.e., they have a constant body temperature. Heat is produced in the body by tissue respiration, the activities of the internal

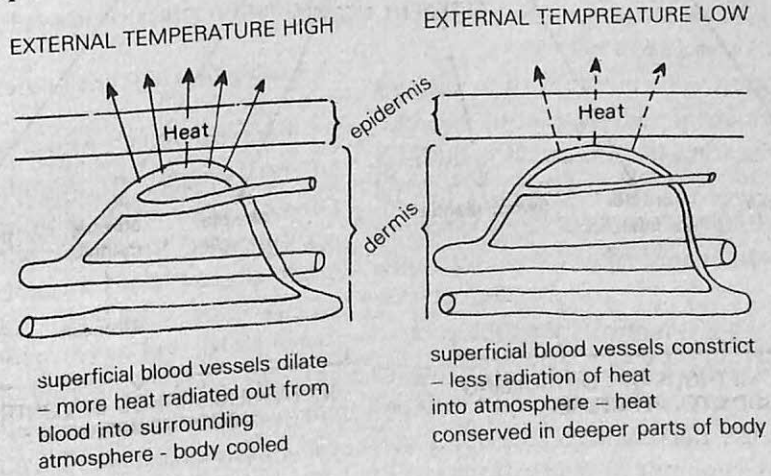
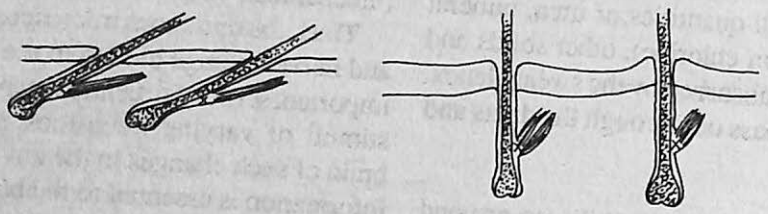


Fig. 2.32 Regulation of body temperature



erector muscles relaxed: hair shaft very oblique in relation to skin surfaces – free circulation of air over hairs (moving air is a good heat conductor)

'X' - point of attachment of erector muscle to hair follicle)

erector muscles contracted, pull on hair follicles at 'X' – hair shafts now perpendicular to skin surfaces. Air (poor conductor of heat), trapped between hairs, acts as heat insulator to warm skin. (similar effect achieved in man by adding layers of clothing).

Fig. 2.33 Erector muscles — retaxed and contracted

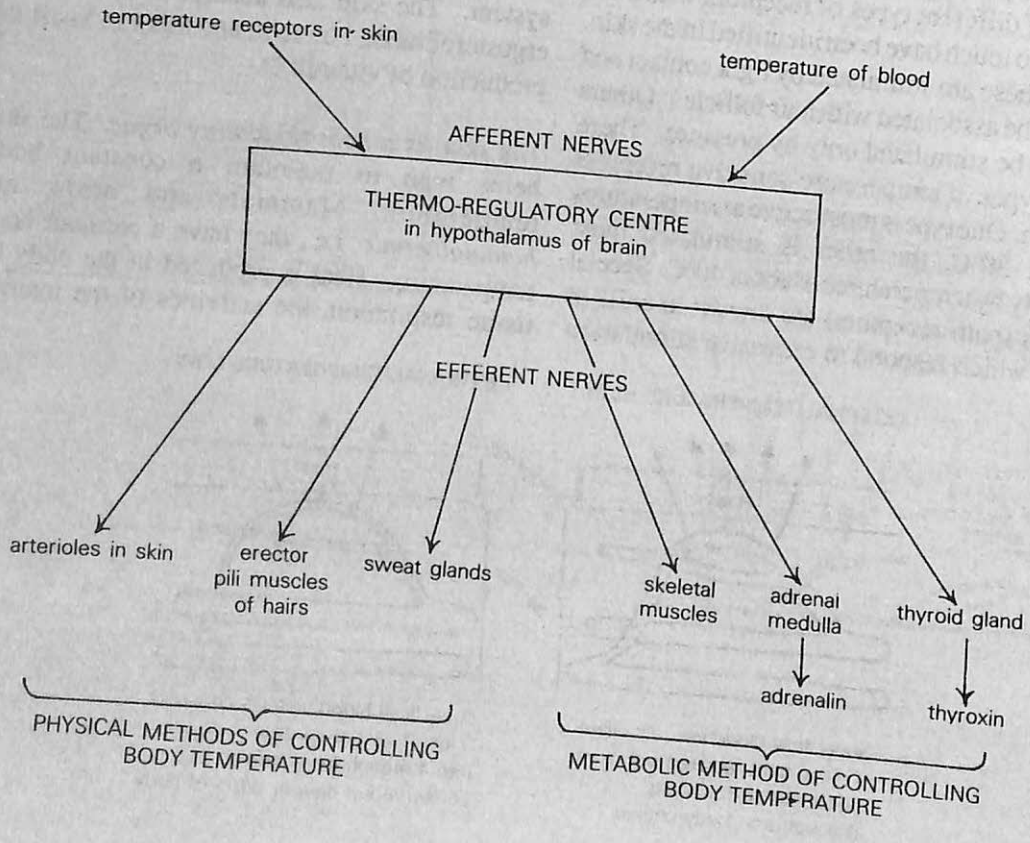


Fig. 2.34 Structures involved in the reflex control by body temperature in man

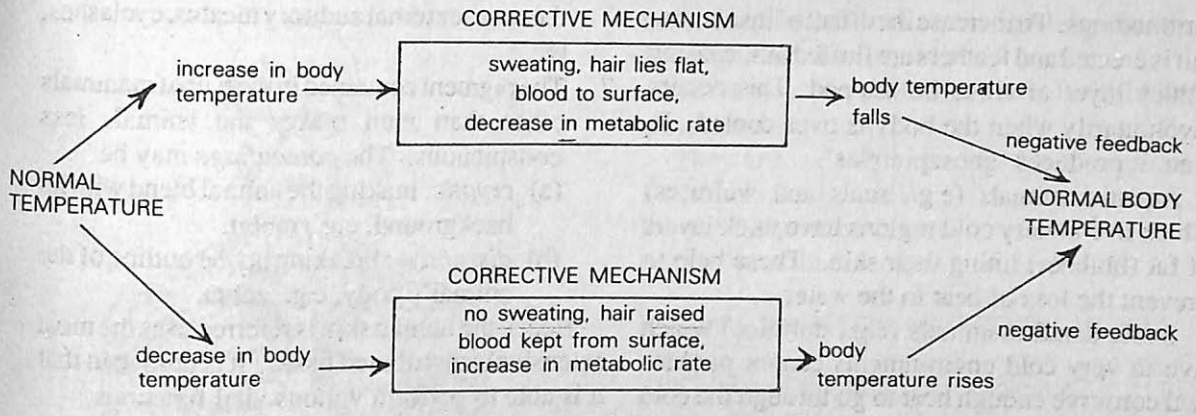


Fig 2.35 The homeostatic control of body temperature in man

organs and muscular exercise and it is distributed to all parts of the body by the blood. The body needs only a certain amount of heat to keep warm. The excess heat is normally lost by urination, defaecation, exhalation, conduction, convection and radiation. When there is a large excess of heat in the body, most of it is got rid of by sweating. Blood flow in the dermal capillaries is stimulated and the sweat glands themselves become more active, extracting large quantities of sweat from the blood. The evaporation of sweat requires heat which is obtained from the body (latent heat of vaporisation). The opposite occurs when the body is over-cooled and contains only a limited amount of heat. Thus little or no sweat is produced so that the amount of heat lost by the evaporation of sweat is greatly minimised.

Fig. 2.36 Panting

REGULATION OF HEAT IN OTHER ANIMALS

The amount of heat lost to the environment by convection and radiation will depend on the amount of blood brought to the surface of the body, as blood is the vehicle of heat transfer. When an animal is hot, the blood vessels under the surface of the skin dilate *(vasodilation)* and more blood is brought to the surface to be cooled. In a mammal with very thick skin, like the elephant, the blood vessels in the ears dilate and more blood is brought to the ears to be cooled. To further facilitate the cooling process, the ears are large and flap continuously. In other mammals, e.g., the dog, the tongue hangs out for a similar purpose. In cold weather, the blood vessels of the skin constrict *(vasoconstriction)* so that less blood circulates through them. Consequently, less heat will be brought to the surface of the body and the amount of heat lost by convection and radiation will be reduced.

A covering of feathers in birds and hair in mammals helps to trap a layer of warm air above the skin. This serves for insulation by reducing heat lost through convection and conduction. In this way, the heat in the body is retained to a certain extent and not allowed to be lost to the

surroundings. To increase the effect of insulation, hair is erected and feathers are fluffed out, causing a thick layer of air to be trapped. This occurs involuntarily when the body is over-cooled. In man, it produces 'goosepimples'.

Aquatic animals (e.g., seals and walruses) which live in very cold regions have thick layers of fat (blubber) lining their skin. These help to prevent the loss of heat in the water.

Some small mammals (e.g., dormice) which live in very cold environments cannot produce and conserve enough heat to go through the cold season normally. They, therefore, pass through this period in a state of stupor, or *hibernation*, during which they sleep in some safe, warm place. The rate of metabolism is minimised.

In man the skin acts as a 'radiator' under control of the brain, regulating the elimination of heat from the body.

OTHER FUNCTIONS OF THE SKIN

1. The skin helps to maintain a constant amount of fluid in the body. When the body has excess water, some of it is got rid of as sweat. If, on the other hand, the body has only a limited amount of water, less sweat is produced so that the body does not become dehydrated.
2. The skin adipose tissue provides a *site for the storage of fat.* When needed, this food reserve is mobilised and distributed around the body in the bloodstream.
3. The skin provides a *definite shape* to the body.
4. It is the organ of absorption for some substances only (e.g., iodine, salts of mercury).
5. The *mammary glands* are modified sweat glands; hence they serve as organs of milk production. The *ceruminous glands* form ear wax. The ear wax helps to trap the dust particles and germs.
6. The skin helps in the *filtering of dust and germs in the air* by means of hair present in the nose, external auditory meatus, eyelashes, etc.
7. The pigment contained in the hair of mammals other than man makes the animals less conspicuous. The *camouflage* may be
   (a) *cryptic:* making the animal blend with its background, e.g., rabbit.
   (b) *disruptive:* breaking up the outline of the animal's body, e.g., zebra.

Hence the human skin is referred to as the most extensively distributed tissue. It is unique in that it is able to perform various vital functions.

2.4 Muscles — outline of structure and function, importance of actin and myosin

Have you heard someone describing a person as being just skin and bones? If he means it literally, how will that person look? What is it which covers the bones and gives the body a beautiful form and appearance? It is the pink mass of flesh that is seen under the skin which we call *muscle.*

The muscles in a living body are very important for it is by their contraction and relaxation that movement of every part of the body, including the limbs and internal organs, is effected. The contractions of muscles are initiated, controlled

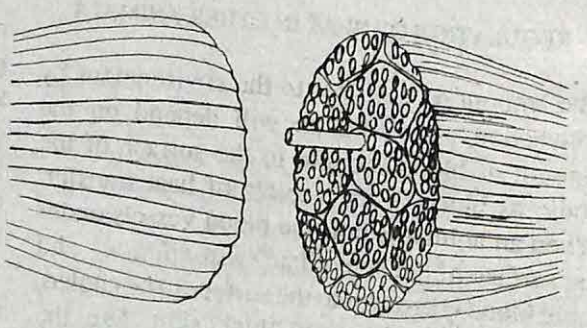


Fig. 2.37 Bundles of muscle fibres

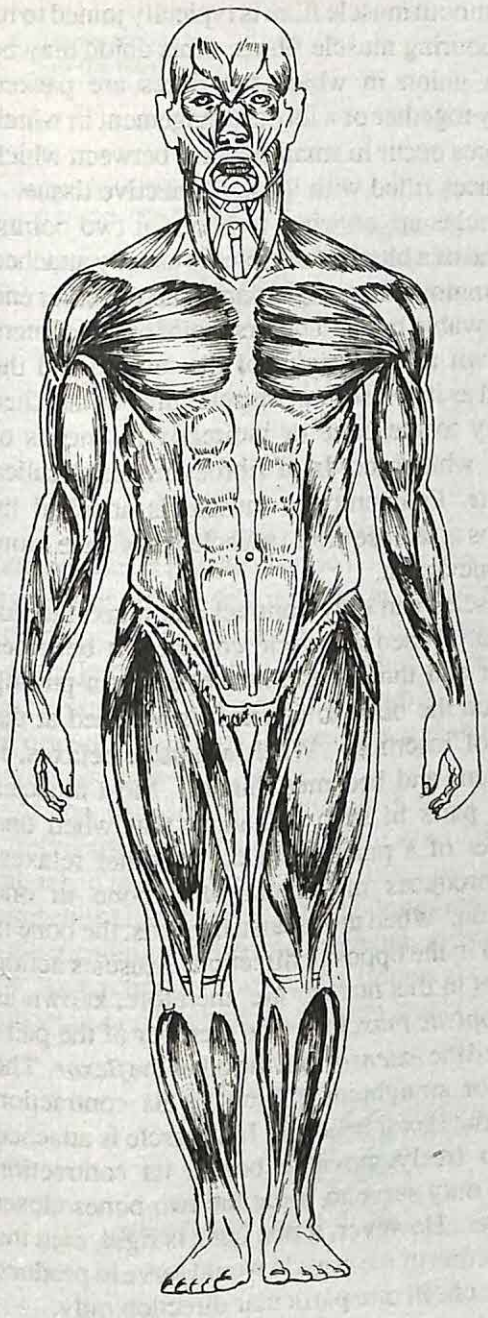


Fig. 2.38 The muscles of the human body (anterior view)

and co-ordinated by the brain and the nervous system. Muscles help to keep the body in an erect posture. Important organs in the body like the heart, lungs and stomach are all muscular in structure and as a result of their contractions vital functions like the circulation of blood, respiration and digestion are carried on.

There are three kinds of muscles in the body of a mammal.

They are,

1. the skeletal muscle,
2. the heart muscle, and
3. the smooth muscle.

1. THE STRUCTURE OF SKELETAL MUSCLE

The fibres of the skeletal muscle are larger than those of the heart muscle or the smooth muscle.

At each end of a muscle, the individual fibres unite with the strands of a tendon, which is attached in turn to a bone or to some other firm

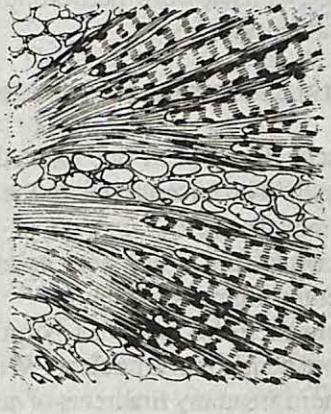


Fig. 3.39 Voluntary muscle.

structure which either anchors the muscle or is moved by the muscle when it contracts.

The human body contains about 600 skeletal muscles, each composed of many individual muscle fibres. Some are large and others are very small. Each muscle fibre is enclosed within a delicate membrane *(sarcolemma)* like a sausage enclosed by a skin.

2. THE STRUCTURE OF CARDIAC MUSCLE

The fibres of the cardiac muscle are smaller than those of the skeletal muscle and are shaped differently. These have blunt ends which are

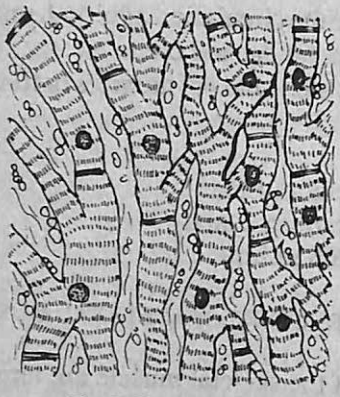


Fig. 2.40 Cardiac muscle

fused end to end with neighbouring fibres. Their fusion with one another forms a firm muscular structure, which, when the fibres contract, causes the chambers of the heart to become smaller. Inside each heart muscle fibre there is one nucleus and considerable cytoplasm.

3. THE STRUCTURE OF SMOOTH MUSCLE

Smooth muscle fibres, with one exception, are relatively small. The exception is in the case of the smooth muscles in the wall of the uterus. During pregnancy, the fibres here enlarge and become several millimetres long.

Smooth muscle fibres taper to a point at each end. Each fibre contains one nucleus. Within the cytoplasm, there are many filaments of *actin* and *myosin*, but these are not as conspicuous as those in the skeletal and cardiac muscles.

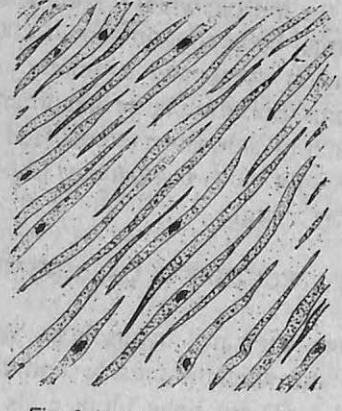


Fig. 2.41 Involuntary muscle

A smooth muscle fibre is typically joined to its neighbouring muscle fibres. This union may be a firm union in which the fibres are packed closely together or a loose arrangement in which the fibres occur in small bundles between which are spaces filled with loose connective tissue.

Muscles are attached to bones at two points. One end of a block of muscles is usually attached to an immovable or rigid bone, and the other end to a movable bone. The first point of attachment is known as the *origin* of the muscle and the second as its *insertion*. Muscles may be attached directly to the bone or indirectly by means of tough, whitish cords of fibrous material called *tendons*. Frequently, a muscle is attached by tendons at its insertion. Muscles may have more than one origin.

Muscles can only contract and relax, but not expand. When a muscle contracts it becomes shorter and thicker and hence, exerts a pulling force on the bone to which it is attached at the point of insertion. When a muscle relaxes, it lengthens and becomes thinner. Most muscles act in pairs in such a manner that when one member of a pair contracts, the other relaxes. This produces movement of a bone in one direction. When the reverse happens, the bone is moved in the opposite direction. Muscles acting in pairs in this manner are, therefore, known as *antagonistic muscles*. One member of the pairs is called the *extensor* and the other the *flexor*. The extensor straightens a limb by its contraction while the flexor bends it. If a muscle is attached to two freely movable bones, its contraction would only serve to bring the two bones closer together. However, if one bone is rigid, then the contraction of the muscle would serve to produce movement in one particular direction only.

MUSCLES OF THE ARM

The large muscle on the front of the arm is the *biceps muscle*. The biceps muscle has two tendons of origin attached to the immovable scapula. It has a large *belly* which lies above the

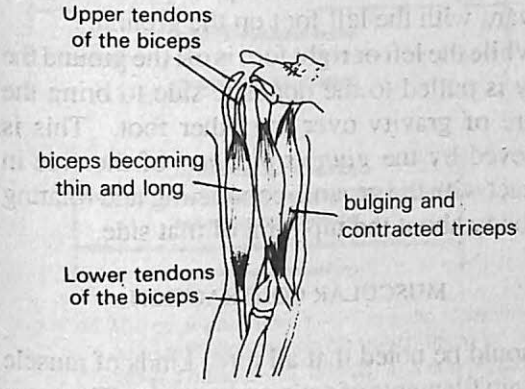


Fig. 2.42 Stretching of the forearm

humerus, but is not attached to it. Just above the elbow joint, the muscle narrows and passes into a tendon (tendon of insertion) which, passing over the joint, is attached to the radius. When the muscle contracts, the radius and, with it, the ulna, are drawn up towards the scapula and thus the forearm is flexed.

At the back of the humerus is the *triceps muscle* with three tendons of origin, one of which is attached to the scapula and the other two to the upper end of the humerus. The tendon of insertion of the triceps is attached to the olecranon process. The contraction of the triceps brings about an extension or stretching of the previously folded

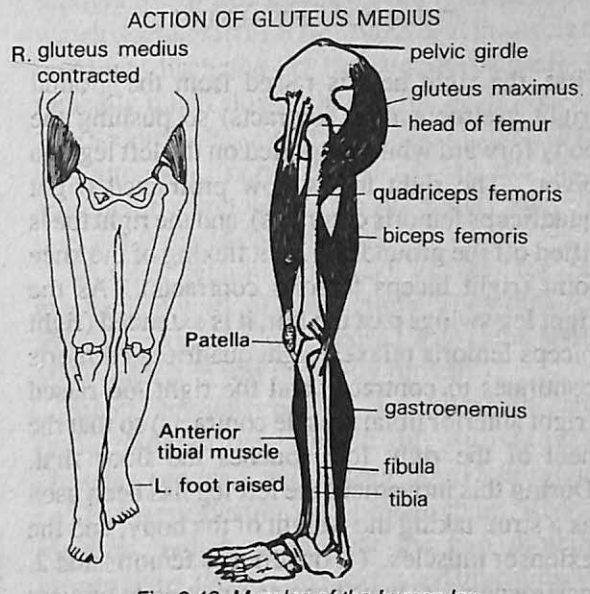


Fig. 2.43 Muscles of the human leg

forearm. The action of the beceps is opposite (antagonistic) to that of the triceps. When one contracts, the other relaxes.

MUSCLES OF THE LEG

Since the legs have to bear the weight of the body while standing, walking and running, they are provided with powerful muscles. When man walks he uses almost all the muscles of the legs (about sixty in each) and many which extend into the trunk.

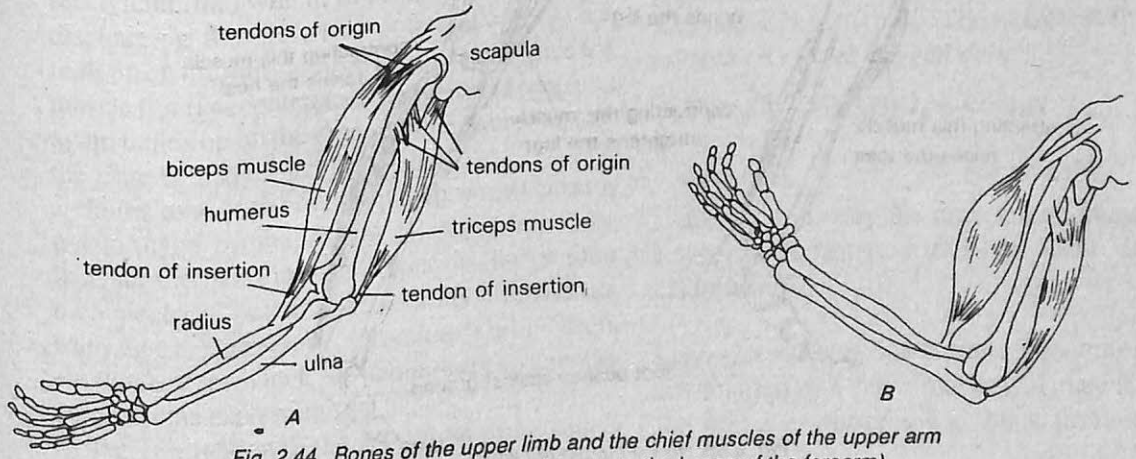


Fig. 2.44 Bones of the upper limb and the chief muscles of the upper arm (how the muscles work to move the bones of the forearm)

THE MODE OF WALKING

First, the right heel is raised from the ground (right gastroenemius contracts) so pushing the body forward while supported on the left leg as a pivot. The right leg is now protracted (right quadriceps femoris contracts), and the right toe is lifted off the ground by slight flexing of the knee joint (right biceps femoris contracts). As the right leg swings past the left, it is extended (right biceps femoris relaxes, right quadriceps femoris continues to contract), and the right toe raised (right anterior tibial muscle contracts) so that the heel of the right foot touches the floor first. During this movement the left leg has been used as a strut, taking the weight of the body, and the extensor muscles. (1. quadriceps femoris and 2. gastroenemius) have been contracting to prevent the collapse of the limb. Also the contraction of the left gluteus maximus helps to pivot the body forward with the left foot on the ground.

While the left or right foot is off the ground the body is pulled to the opposite side to bring the centre of gravity over the other foot. This is achieved by the *gluteus medius* of the side in contact with the ground, contracting and rotating the body about the hip joint of that side.

MUSCULAR CONTRACTION

It should be noted that all three kinds of muscle contain filaments of actin and myosin. These are the substances which, when properly activated, bring about the shortening of a muscle fibre. It is presumed that at the time of contraction electrostatic charges develop which cause the actin and myosin filaments to be attracted to each other. However, this attraction causes the

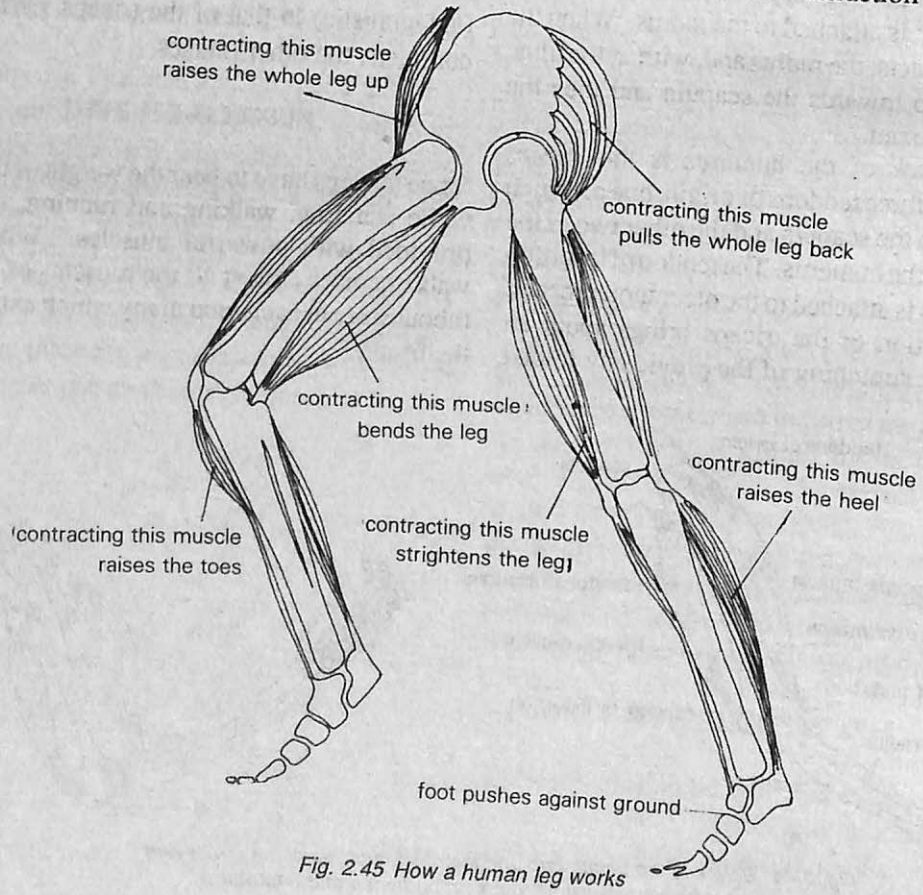


Fig. 2.45 How a human leg works

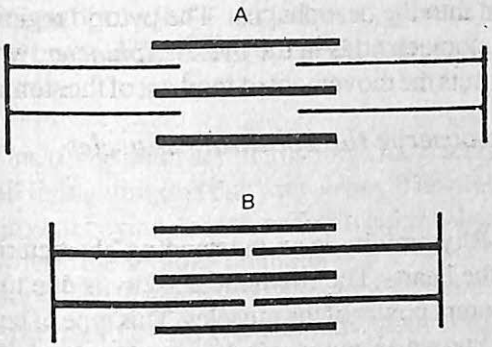


Fig. 2.46 Muscular contraction — The actin filaments (thin) and the myosin filaments (thick) — (A) in a relaxed muscle cell, and (B) in a contracted muscle cell

filaments to move parallel to each other rather than bringing them into mere contact. The filaments interdigitate in a manner which you can illustrate by placing the tips of the extended fingers of your right hand between the tips of the extended fingers of your left hand and then moving the two hands closer to each other as the fingers of one hand slide into the spaces between the fingers of the other. Such an action of the actin and myosin filaments causes the entire fibre to shorten.

In the case of the skeletal muscle, the contraction of each fibre is initiated by a nerve impulse. In other words, every fibre of the skeletal muscle is served by a small branch of a nerve. When a nerve impulse arrives at the muscle fibre, it releases a chemical substance (acetylchlorine) which, in turn, has the effect of discharging the electrical potential which has built up on the muscle fibre membrane. Once the muscle fibre has contracted, the electrical potential again builds up on the external membrane so that the fibre is ready to contract again.

In the case of the heart muscle, contraction is not initiated by the arrival of nerve impulses. Instead, the heart muscle fibres discharge their own electrical potential as soon as it builds up, following the previous contraction. This inherent *rhythmicity* provides for about sixty to seventy contractions each minute.

The contraction of the smooth muscle fibre is brought about in a manner quite similar to that which operates in heart muscles. But the cycle of build-up discharge in the smooth muscle is typically much slower than in the heart muscle. The action of the smooth muscle is influenced by the autonomic nervous system. In the heart muscle the autonomic impulses merely alter the rate and force of contraction.

Muscles require chemical energy for the mechanical work of contraction. They obtain it from the oxidation of glucose. Muscle is about 80% water, the rest is mostly protein.

Small amounts of fat and glycogen, and two phosphorus-containing substances, *phosphocreatine* and *adenosine triphosphate* (ATP) are muscle fibre in a protein chain. Recent research studies reveal that the two proteins *myosin* and *actin* have been extracted from muscle, but they are not capable of contraction, alone. Only when they are combined to form a thread of actomyosin and when potassium, calcium and ATP are added, the actomyosin undergoes contraction.

An analysis of the biochemical changes that occur during muscle contraction shows that during contraction, glycogen, oxygen, phosphocreatine and ATP decrease and carbon dioxide, lactic acid, adenosine diphosphate and inorganic phosphate increase.

If the muscular exercise is severe and prolonged, accumulation of lactic acid may prevent the muscle from contracting further, and it is said to be *fatigued*. The muscle is then said to have *increased oxygen debt*.

$$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3 + \text{Energy}.$$

Glucose Lactic acid

During recovery the muscle continues to use oxygen at a fast rate until the lactic acid has disappeared.

Sphincter muscles: The entrance of some openings are guarded by a valve-like ring of muscles called the *sphincter muscles*, e.g., anus, urethra, etc.

The entrance to the cardiac region of the stomach is guarded by the *cardiac sphincter*. This arrangement prevents the regurgitation of food into the oesophagus. The pyloric region of the stomach ends in the *pyloric sphincter* which restricts the movement of food out of the stomach.

Activity 8: *Devise a simple experiment to observe the voluntary muscles twitching in a frog.*

CARDIAC MUSCULAR CONTRACTION

The heart muscles possess some properties of visceral and somatic muscles. The heart muscle exhibits excitability and contractility.

Rhythmicity is an outstanding characteristic of the heart. The rhythmic activity is due to the inherent power of the muscles. This type of hearts are known as *myogenic* hearts. Conductivity is the properly of all heart muscles.

Activity 9 : *What are neurogenic hearts? Name the animals which possess this type of heart.*

Activity 10: *Find out the various abnormal condition of muscles such as muscular hypertrophy, disuse atrophy, paralysis and muscular dystrophy.*

Activity 11: *Remove the skin from the thorax, abdomen, arm and leg of one side of rat. Is it attached with equal firmness everywhere? Observe some of the major muscles.*

Structural differences
(Skeletal, Cardiac and smooth muscles)

Skeletal	*Cardiac*	*Smooth*
1. The muscle cells are called muscle *fibres* which are cylindrical. 2. There are many nuclei (multinucleated) which are situated towards the periphery or edge of the fibre.	1. The muscle fibres are cylindrical and branched. 2. It has one or two centrally located nuclei.	1. The muscle fibres are spindle-shaped. 2. It has only one centrally located nucleus(uninucleate).

Functional differences

The skeletal muscles help in the movement of different parts of the body such as hands, legs, eyes, facial muscles, etc.	The heart muscle fibres are branched, so that its contraction can spread to all the fibres throughout the heart.	The smooth muscle is found in all the visceral organs (internal organs, e.g., urinary bladder, etc.) These muscles help in *peristalsis* or contraction of the stomach, so that the food moves down the alimentary canal.

Animal growth — variation of growth in the body, external or internal factors for growth

One of the chief distinguishing characteristics of all living things is that they *grow*. The process of growth begins as soon as fertilisation takes place where the zygote undergoes a series of well-organised, irreversible changes which eventually give rise to a fully formed individual. *This series of changes in a body causing an increase in size and shape is known as growth.*

After birth, growth continues internally in the cells and externally in the size of the individual. An elaborate series of changes called development transform the infant to the adult, causing ageing and finally death. Thus, development includes the entire life span of an individual, right from the formation of gametes till the death of the individual.

For any sort of growth to take place, the cells in the individual have to continually grow and multiply, die and be replaced by new cells. Most animal cells undergo rapid cell division and cell differentiation but unlike plant cells, they undergo very little cell enlargement.

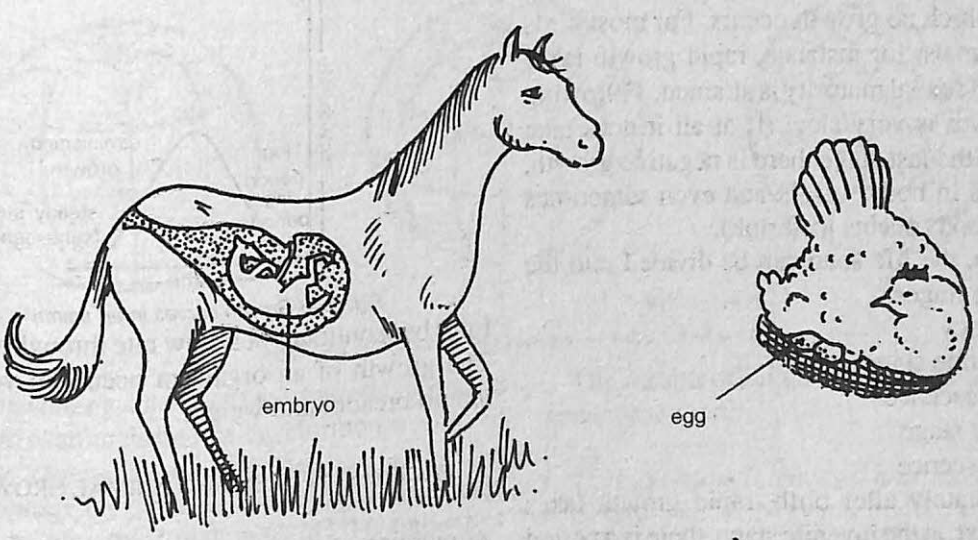


Fig. 2.47 Types of development, A. internal development in a horse, B. external development in fowl

External development : Several animals, for instance, fishes, amphibians, reptiles and birds, show external development.

The fertilized eggs contain reserve food or yolk for their development. In birds, the young ones develop only at a particular temperature. The same temperature is provided by parents who sit on the eggs. The phenomenon is called *incubation*. True internal development occurs in most of the mammals (e.g., man, dog).

Internal development: In viviparous animals the eggs are small and develop in the uterus of the female reproductive system. The foetus is attached to the uterine wall by means of the *placenta* and an *umbilical cord*. The foetus obtains nourishment from the mother by diffusion.

Activity 12: *Collect pictures of four oviparous and viviparous animals. Compare their growth and development. Exchange your views with your classmates.*

GROWTH PATTERNS IN ANIMALS

The pattern of growth varies in different species of animals. Most invertebrates (e.g., cockroaches, lobsters) and even a number of vertebrates (e.g., turtles, fish, reptiles) have a period of unlimited growth. The rate of growth slows down only with increasing age. Animals which moult, e.g., snakes, insects, show rapid growth in the period immediately after moulting, i.e., before the new exoskeleton begins to harden.

Birds and mammals have a period of limited growth, i.e., they can reach a maximum size beyond which no growth occurs. For most birds and mammals, for instance, rapid growth takes place until sexual maturity is attained. Following this, growth is very slow (if at all it does take place). In the last stage there is negative growth, i.e., a loss in body weight and even sometimes size (the body seems to shrink).

In man, the life span can be divided into the following stages

1. infancy
2. juvenile stage
3. adolescence
4. adult stage.
5. senescence

Immediately after birth, rapid growth takes place. Next, at the juvenile stage, there is a period of slow growth. During adolescence, when sexual maturity is attained, there is a period of very rapid growth. During the adult stage, there is barely any growth. This is followed by loss of weight during senescence and finally death.

Not all parts of an animal grow at the same rate. For instance, the human head and brain develop very rapidly during the earliest stages of life and then cease to grow. The rest of the body then continues to grow until adolescence is completed, after which growth in height ceases.

Thus the growth of an individual is never uniform. Initially the growth is slow. It is called the *lag period*. It is followed by a period of rapid growth. The phase of rapid growth is called *log period*. Soon after, the rate of growth never stops

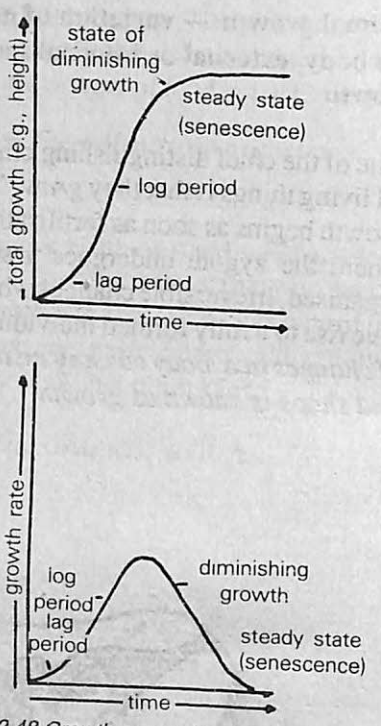


Fig. 2.48 Growth curves in an animal

fully but continues at a slow rate throughout life. The growth of an organism occurs in volume, length breadth and weight.

FACTORS INFLUENCING ANIMAL GROWTH

A number of factors influence the growth of animals. You know that animals do not manufacture their own food from simple compounds (like plants do). This is because the nutritional requirements of animals are more complex than those of plants. Thus, the availability of the right type of nutrients in the right proportion plays an important part in the growth of animals. An interesting instance of this is the case of the Japanese people who were known to be short-statured though they possessed the ability for normaly growth. Their short stature was due to a protein deficiency in their diet. As soon as this was detected steps were taken on a large scale to supplement it in their diet. Within a couple of generations the normal height of the race was restored.

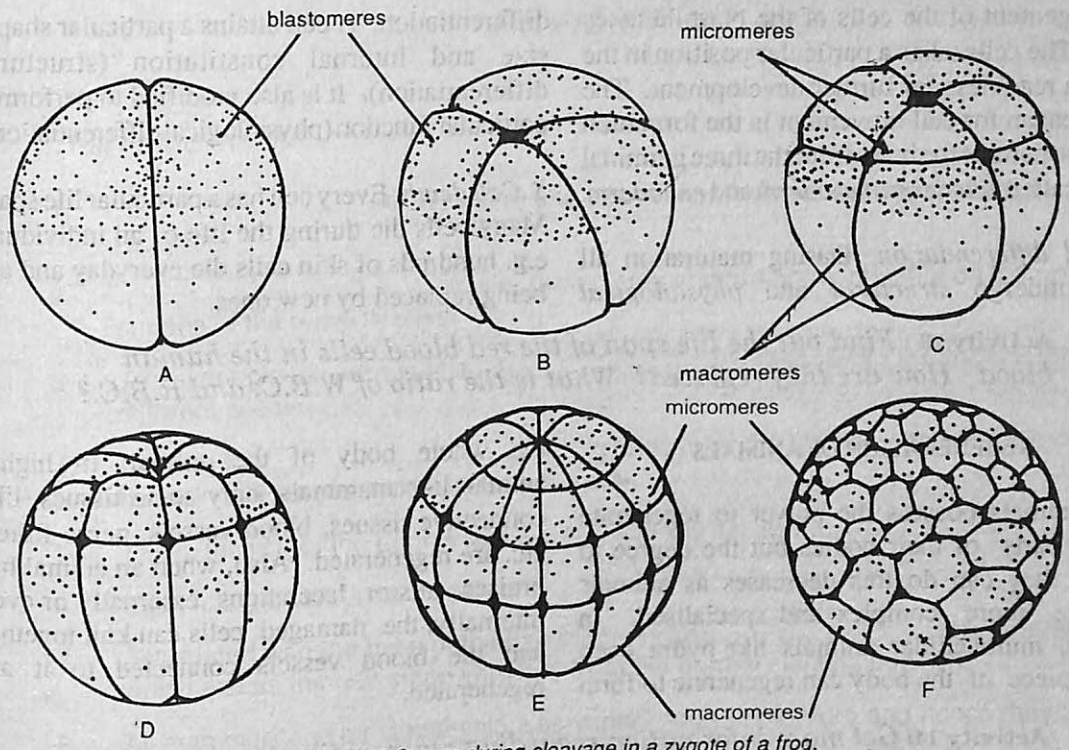


Fig. 2.49 Stages during cleavage in a zygote of a frog.

Hormones are another factor which affect the growth of animals internally. Hormones secreted by the *thyroid gland*, the *pituitary gland* and the *gonads* (sex glands) are mostly concerned with the growth of mammals. If the amount of hormones secreted is less, more abnormalities of growth like dwarfism and gigantism may occur.

Another type of abnormal growth which occurs in cells is *cancer*. Cancer is a *tumour*. A tumour is an unusual amount of growth or enlargement of a tissue due to uncontrolled and repeated division of some cells. Tumours can develop anywhere on the surface or the interior of the body. Cancerous or *malignant* tumours spread very fast to neighbouring tissues and are often fatal.

Some chemicals (called *carcinogenic agents)* have been found to induce cancer. They include nicotine, caffeine, X-rays, nuclear fall-out and several polycyclic hydrocarbons.

The mystery of a particular sequence in growth and development can be found only if the changes in the cells are studied at various levels.

The various cellular events which occur during development are:

1. Cell division (cleavage and blastulation) : After fertilisation, the zygote divides and redivides mitotically to form a small ball of cells called the blastule. This phase of development is called *cleavage*.

The mitotic division of most cells stops when the animal reaches its maximum growth. However in some regions of the body, e.g., skin, hair, nails, mitosis continues throughout the life of the individual as new cells are constantly being formed.

2. Cell enlargement or cell elongation: Animal cells (unlike plant cells) show very little cell enlargement. Exceptions are a few muscle cells and nerve cells.

3. Cell movement: During embryonic development, a large-scale movement and

rearrangement of the cells of the blastula takes place. The cells takes a particular position in the body in readiness for further development. The main reason for cell movement is the formation of all the parts of the body from the three germinal layers called *ectoderm*, *mesoderm* and *endoderm*.

4. Cell differentiation: During maturation all cells undergo *structural* and *physiological* differentiation. A cell attains a particular shape, size and internal constitution (structural differentiation). It is also modified to perform a particular function (physiological differentiation).

5. Cell death: Every cell has a particular life span. Many cells die during the life of an individual, e.g. hundreds of skin cells die everyday and are being replaced by new ones.

Activity 13 : *Find out the life span of the red blood cells in the human blood. How are they replaced? What is the ratio of W.B.C. and R.B.C.?*

REGENERATION OF ANIMALS

All animals possess the power to regenerate 'lost' parts of their bodies but the degree to which they can do this decreases as animals become more complex and specialised. In simple, multicellular animals like hydra, even a tiny piece of the body can regenerate to form the whole body of the animal. In higher animals like mammals, only some tissues, like connective tissues, blood vessels, nerve fibres, etc. are regenerated. Also, when an animal has bruises, cuts or lacerations externally or even internally, the damaged cells can knit together and the blood vessels connected to it are regenerated.

Activity 14: *Get more information regarding regeneration in animals. Give a microlecture on 'regeneration' to your classmates.*

Some basic concepts

1. The bodies of animals are composed of several distinct tissues — epithelial, vascular, muscular, connective and nervous tissues, etc.,
2. Muscles cover the skeletal structures and give the human body its shape.
3. The muscular system is extensive. The muscle cells possess the ability to contract. Muscle proteins, actin and myosin, are associated with the contractile mechanism.
4. Growth and development take place in all living cells externally and internally in all living cells and organisms.
5. The various cellular events which occur during development are 1. cell division, 2. cell enlargement, 3. cell movement, 4. cell differentiation, and 5. cell death.

Some suggested projects/activities

1. *Find out why an athlete 'warms up' before going out to compete.*
2. *Examine prepared sections of mammalian skin microscopically. Compare the appearance of the scalp skin of man with skin from elsewhere on the body.*
3. *Examine the nature of skin in other vertebrates — fishes, amphibians, reptiles and birds. Relate the differences in skin structure to the modes of life of these animals.*

REVISION

I. *Fill in the blanks.*

1. ..... are very long and stout hair which act as extended touch receptors.
2. ..... are very thick plates of dead horny material on the upper surface of the terminal digit.
3. The scent glands are modified ..... glands used for distinguishing different species.
4. Oil from the ..... glands maintain the hair shaft in good condition by making it supple and less liable to break.
5. The extension of the dermis into the epidermis is called ..... .
6. Each hair grows from a pit called ..... .
7. Associated with the base of the hair follicle is an ..... , the contraction of which makes the hair stand vertically from the normal slanting position.
8. All mammals and birds maintain a constant body temperature and hence they are called ..... .
9. Some animals have body temperature that fluctuates with the temperature of the environment and they are known as ..... .
10. ..... is the outermost part of the skin which consists of several layers of epidermal cells.

II. *Distinguish between*

a. epidermis and dermis

b. sweat gland and sebaceons gland

c. homoiotherms and piliotherms.

d. hibernation and aestivation.

e. biceps and triceps muscles.

III. *Answer the following questions.*

1. Write short notes to describe the main features of

   i. epithelial tissue. ii. connective tissue. iii. vascular tissue. iv. muscular tissue. v. nervous tissue.

2. Differentiate clearly between striped, unstriped and cardiac muscles.
3. Define the term 'tissue'.
4. What are the functions of epithelial tissues?
5. What are the structural peculiarities of the connective tissue, bone and cartilage?
6. What is the most important function of blood? How is it suited to carry out this function?
7. What is special about muscle tissue? Name kinds of muscles within the body.
8. The structure of a cell is adapted for its functions. Examine the nerve cell in the light of this statement.
9. What are actin and myosin?
10. Point out the location of the abdominal muscles, gastroenemius, triceps and biceps.
11. Describe the structure of the skin as seen in a vertical section.
12. Enumerate the functions of human skin.

IV. Give scientific reasons for the following:

1. During winter we consume more food.
2. When exposed to extreme cold, we shiver.
3. Mammals and birds have successfully conquered the environment of even the Arctic and the Antarctic.
4. Most people in the cold regions suffer from vitamin D deficiency diseases.

3. Nutrition and hygiene

Nutrition and hygiene - menace of adulteration of food and medicines.

Many diseases and toxicities are caused by neglect of sanitation and unhygienic handling of food stuff. Therefore, some knowledge of food hygiene and sanitation is a must for every person. It will be useful to know how our food gets contaminated with harmful substances and organisms, their effects and the methods of preventing the same.

Activity 1: *Find out the symptoms of anaemia, goitre and mental retardation.*

3.1 Menace of adulteration of food and medicines

Activity 2: *Collect paper cuttings about legal cases of adulteration of food and medicines.*

The mixing of undesirable substances in food is called *food adulteration.* It is a serious health hazard because many of the adulterants have harmful effects on the body and brain. Food adulteration is carried out by dishonest persons engaged in the production and supply of food articles.

THE REASONS FOR FOOD ADULTERATION

1. The rising costs of living tempts the trader to make cheap money.
2. Declining moral values.
3. Scarcity of food due to comparatively less increase in its production as compared to the growth of population. The producer or trader is tempted to increase the quantity of food by addition of cheaper and undesirable substances to meet the rising demand.
4. Improper and unscientific storage of food materials.
5. There is a lack of serious resistance to adulteration. People are quite indifferent towards quality of materials supplied to them. This is due to the psychology of scarcity and ignorance of the effects of adulteration.
6. There always are middlemen between the producer and the consumer. Handling by many persons tends to increase the chances of exposure to adulterants and results in all sorts of malpractices.

7. Unscrupulous traders use all kinds of adulterants which are not easily detected.
8. There is no system of immediate detection of adulteration in most food articles.

EFFECTS OF ADULTERATION

Various types of adulterants are mixed in food regardless of the harmful and dangerous consequences.

Edible oils are mixed with mineral oils and argemone (wild poppy or prickly poppy) oil. This has caused severe health problems in several parts of the country. The symptoms are swelling of limbs, rash all over the body and gastro-intestinal disorders. In several cases even death occurs. Plasticiser tricresyl phosphate was mixed with edible oil in some parts of our country. It produced paralysis in many families. A common adulterant is the use of non-edible dyes in the preparation of sweets, puddings, etc. Coal tar dyes and other colouring materials may cause cancer. Starch powder coloured with lead chromate or metanil yellow is added to turmeric powder. Lead chromate damages the nervous system and produces anaemia. Stiff limbs and paralysis occur quite often, besides permanent damage to the brain.

Methyl alcohol tincture or even varnish is added to liquor to give it extra colouration and make it more potent. It has deprived many people of their eyesight, hearing, speech and vitality, and has even killed many persons.

Activity 3: *To detect vanaspati (vegetable oil) in ghee, dissolve one spoon of sugar in two spoons of dilute hydrochloric acid. Add 10 ml of ghee. The pink colour indicates the presence of vanaspati.*

STEPS TO PREVENT ADULTERATION

It is wise to purchase food items in packets bearing ISI or Agmark labels with dates of manufacture and expiry. The seal and date of expiry must be checked at the time of purchase. Spices and condiments should be powdered at home. Artificially coloured food articles should be avoided.

An act was passed by the Parliament in 1954 to make adulteration a legally punishable offence. It is known as the Prevention of Food Act, 1954. A number of laboratories have been set up to analyse food stuff for adulteration. Samples of food stuff are regularly taken and tested for adulteration. The system of on-the-spot punishment has been used in cases of milk adulteration. Social boycott of traders indulging in adulteration, immediate reporting to higher authorities, etc. are some of the suggested measures to prevent them from repeating such acts.

Common adulterants and their detection

	Food stuff	*Adulterants*	*Detection*
1.	Cereals	stone, sand straw, husk or insect infested grains.	Take about 50 g of food grains. Pick up the foreign matter by hand or with forceps. Insect infested grains float on the surface of water.
2.	Black pepper	dried seeds of papaya.	Papaya seeds float on the surface of water while pepper seeds sink.
3.	Chilli powder	saw dust, brick dust.	Saw dust floats on water. Burn the chilly powder if you suspect brick dust. The large residue will indicate brick dust.
4.	Asafoetida	foreign gum; starch	Asafoetida dissolves in water to produce a milky solution. It also burns with a bright flame.

Adulteration in medicines can be of two types:

1. *non-toxic*
2. *toxic*

Non-toxic: A capsule or a tablet can be made impure or dangerous just by the addition of an extra dose of any of its component, even glucose.

Medicines used after their date of expiry may, in some cases, lead to drastic results. Injections and vaccines especially that of polio should not be used after the expiry date. It may not only fail in its purpose but may also cause damage to vital organs like the brain.

Effects of use of non-toxic substances:

1. The patient will not get the medicine that he actually needs.
2. The disease will progress.
3. Doctors will be confused about the symptoms.

Toxic : 1. The chemical composition of the medicines may be different. 2. A sub-standard quality of the original medicine may be used.

Effects of using toxic substances:

1. Apart from the ailment the patient is already suffering from, he may develop others. For instance, when a spurious drug is administered, the patient may develop jaundice.
2. When substandard drugs are used the required dosage is not taken in and the germs will develop resistance to the drug, making the drugs useless.
3. In some cases of adulterated medicines being given as injections, it may result in instant death.
4. If glucose drips are not carefully prepared, it will cause fever.
5. If distilled water used in injections, etc. is not pure, abscesses may form at the site of the injection.

Some basic concepts

1. The mixing of undesirable substances in food is called food adulteration.
2. Some of the adulterants do not pose any health problems (e.g., starch, straw, etc.). They are only a cause of irritation, extra labour and loss of money.
3. Some undesirable substances of food adulteration are very harmful.
4. A comprehensive act passed by the Parliament in 1954 makes adulteration a legally punishable offence.

Some suggested projects / activities

1. *Find out the adulterants used in turmeric powder.*
2. *If turmeric powder contains lead chromate as an adulterant, how will you detect it? Can you devise a method to detect this particular adulterant?*
3. *Try the following method to detect chromate salt in turmeric powder:*
   Take about 2 g of turmeric powder and heat at 600°C in a china dish. An ash is obtained. Dissolve the ash in 5 ml of dil. H_2So_4 *(1:7) and filter the mixture. Add a few drops of 0.2% alcoholic diphenyl carbazide. A pink colouration indicates chromate.*
4. *If you suspect metanil (a kind of coal dye) in turmeric powder, do the following test to detect the same:*
   Dissolve some turmeric powder in water in a test tube. Add a drop or two of hydrochloric acid. The solution becomes magenta coloured. Dilute it with water. The colour will persist, showing the presence of metanil.

REVISION

I. *Questions:*

1. Define food adulteration. Why is it prevalent in India?
2. Discuss the effects of food adulteration.
3. What are the common adulterants of milk, ghee, tea leaves, cereals and pulses? How can you detect the most common adulterants in them?
4. What can you do to check food adulteration?

II. *Fill in the blanks.*

1. ..... is a complex of organic and inorganic substances that is required for growth and maintenance of an organism.
2. The ..... of undesirable substances in the food is called adulteration.
3. The ..... is tempted to increase the quantity of food by addition of cheaper and undesirable substances in order to meet the rising demand.
4. ..... is an instrument to detect the purity of milk.

4. Reproduction - inheritance and evolution

Alternation of generation- hydra sexual forms - early development in frog - metamorphosis (butterfly and frog) - fertilisation - reproduction in animals - union of male and female gametes (in fish, frog, birds and mammals) - breeding season - other methods - gemmules (sponges) - regeneration - wound healing - perpetuation of the human species; population explosion - parental care - meaning and need - examples.

Living organisms reproduce in several ways. Reproduction always begins with the formation of a *reproductive unit*. This unit may be produced from one parent or may involve two parents. The unit then goes through a series of developmental changes to give rise to the body of the offspring which resembles the parents.

Heredity is the transmission of characteristics from parents to offspring and the science of heredity is known as *Genetics*. Genetics deals with resemblances and differences of related organisms flowing from the interaction of their genes and the environment.

The idea of evolution is ancient. It was, indeed, none other than Aristotle who emphasized the gradual change from simple or, as he put it, 'imperfect' forms to complex or 'perfect' forms.

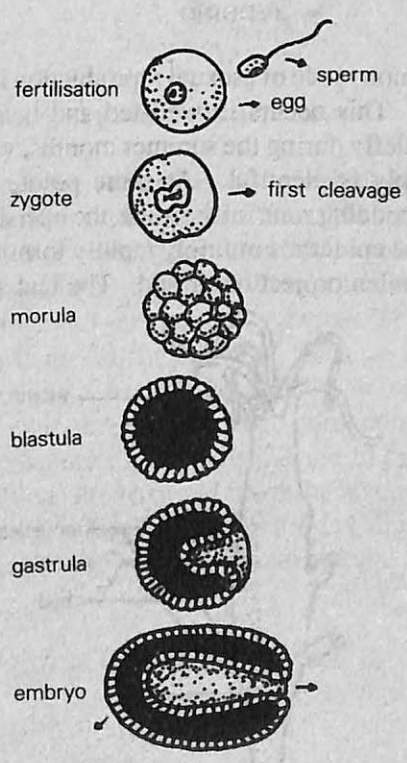


Fig. 4.1 From fertilisation to the embryo stage

4.1 Alternation of generation (hydra)

Coelenterates exhibit two different morphological types of individuals, the *polyp* and the *medusa*. The polyp is sessile (attached to substratum) while the medusa or jelly fish type is free-swimming. Some coelenterates show only the

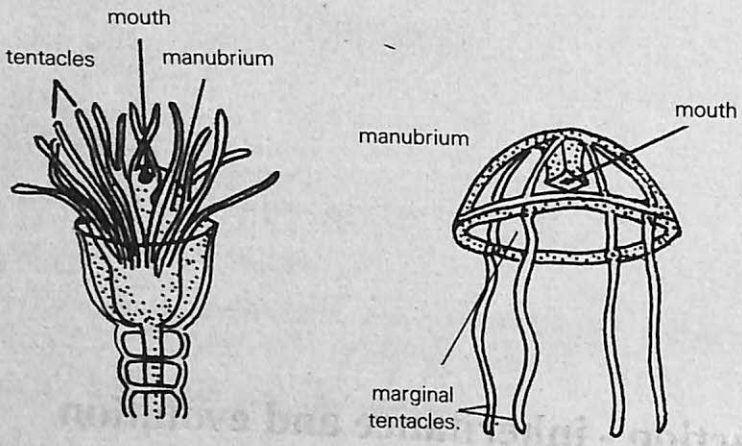


Fig. 4.2 Two morphological types in Hydra. A—Polyp. B.—Medusa.

polypoid form, while others show only the medusoid form. Some pass through both forms or states in their life cycle with an *alternation of generation.*

BUDDING

The common mode of asexual reproduction is by *budding*. This occurs in well-fed and healthy hydras chiefly during the summer months, when food supply is plentiful. At some point, in a definite 'budding zone' of the trunk, the interstitial cells in the epidermis multiply rapidly forming a slight swollen projection or bud. The bud soon

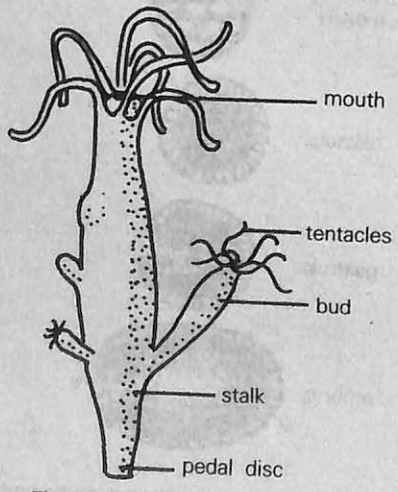


Fig. 4.3 Budding in Hydra

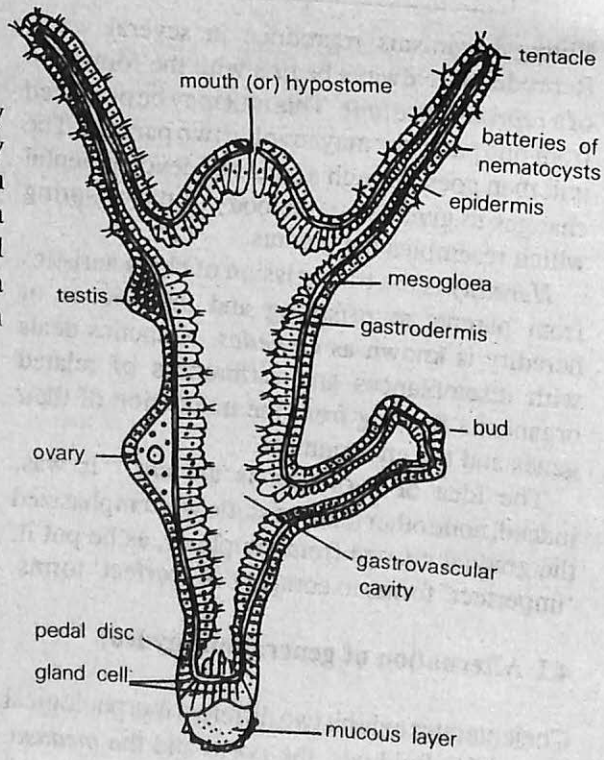


Fig. 4.4 L.S. of Hydra (diagrammatic)

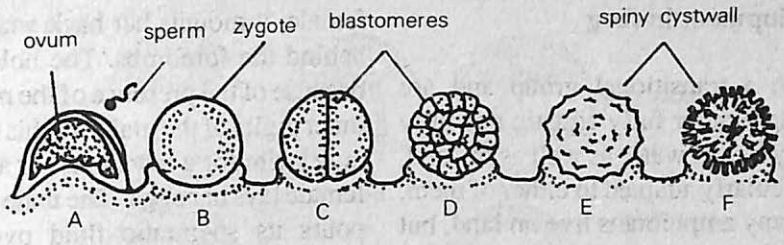


Fig. 4.5 Stages of development

develops a mouth and tentacles. When fully grown, the bud is constricted at the base. It finally separates completely from the parent and begins an independent existence. Occassionally several buds may occur at the same time.

SEXUAL REPRODUCTION

The Hydra reproduces sexually by the fusion of gametes. This is rare and seasonal in Hydra. The gonads are formed temporarily and both ova and spermatozoa are developed from the interstitial cells in the epidermis. The gonads producing *spermatozoa* are called *testes*. Several of them are usually formed in the upper part of the body, near the *hypostome* (mouth). The *ovaries* are the glands in which the ova are formed. These are formed towards the lower end of the body.

Mature sperms are discharged from the testes and swim about in water until they approach protruding ovum and surround it. Several sperms may penetrate the gelatinous covering, but only one enters the ovum and fuses with it completely. This process is called *fertilisation* and the fertilised ovum is called a *zygote*. Development begins while the zygote is still attached to the parent. In the meanwhile, the ectodermal cells secrete a two-layered protective *shell, cyst* or *theca* around

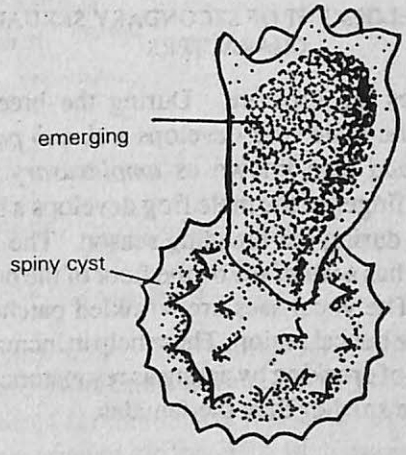


Fig. 4.6 Young hydra hatching

the embryo. The outer layer is thick and spiny while the inner layer is a thin gelatinous membrane. The encysted embryo remains dormant for many weeks. It can withstand both very high and very low temperatures. This resting stage is useful for dispersal, because it can be carried (by currents or by wind, or in the mud on the feet of certain animals) to other ponds where water is present. With the advent of favourable conditions of water and warmth, development is resumed. The embryo hatches out directly into the adult without any metamorphosis.

Activity 1: *Observe the prepared slides of Hydra, L.S. of Hydra, polyp, medusa and identify the different parts.*

Devise a method to culture Hydra in your laboratory. Use a powerful hand-lens to observe the different parts.

4.2 Early development in frog

Amphibians are a transitional group and are peculiar in being neither fully aquatic nor fully terrestrial. They live in water as well as on land, but are not particularly adapted to either of them. It is true that many amphibians live on land, but it must not be forgotten that they are born in water. In fact, amphibians are primarily aquatic.

DEVELOPMENT OF SECONDARY SEXUAL CHARACTERS

The sexes are separate. During the breeding season, the male frog develops a *thumb pad* or *nuptial pad* also known as *amplexusory pad:* The first finger of the male frog develops a black swelling during the breeding season. The male frog also has a *vocal sac* on the floor of the buccal cavity. The vocal sacs are wrinkled patches of skin in the buccal region. These help in increasing the pitch of croaking by acting as resonators. The males are smaller than the females.

AMPLEXUS

This is the sexual embrace between the male and the female frogs which was formerly called *copulation.* During the breeding season both male and female frogs swim frequently in water. The male frog croaks loudly while swimming. If it does not receive a croak in reply from a passing female, it mounts her back and holds her firmly behind the forelimbs. The hold is strengthened because of the presence of the nuptial pads on the inner digits of the male. In this condition the pair may swim for a few hours, or a few days, till the female lays her eggs. The male frog immediately pours its spermatic fluid over the eggs and separates from the female.

FERTILISATION

Fertilisation is external. The nuclear part of the sperm fuses with the egg nucleus to accomplish fertilisation. The fertilised egg is called a *zygote.*

The egg stage: The egg mass is called the *frog's spawn.* The albuminous covering of the eggs swell up in the water to form a jelly-like substance around the eggs. The jelly of the frog's spawn is protected in nature. It is almost impermeable to substances other than water, and so it protects the eggs from microorganisms and water animals. It also helps the eggs to float and stick to some solid object. Each egg contains reserve food for the development of the embryo.

DEVELOPMENT OF THE FROG

The adult frog develops from a single fertilised egg. This development takes place in two steps — formation of the tadpole and metamorphosis of the tadpole.

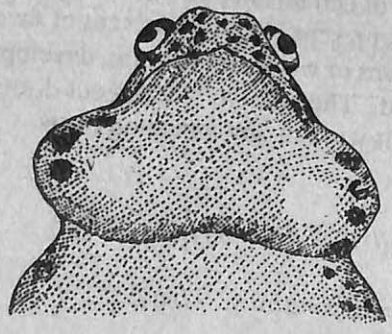


Fig. 4.7 Male frog with inflated vocal sacs

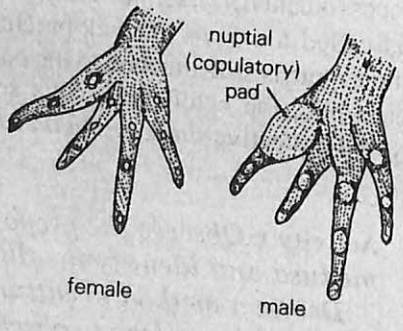


Fig. 4.8 Hands of male and female frogs

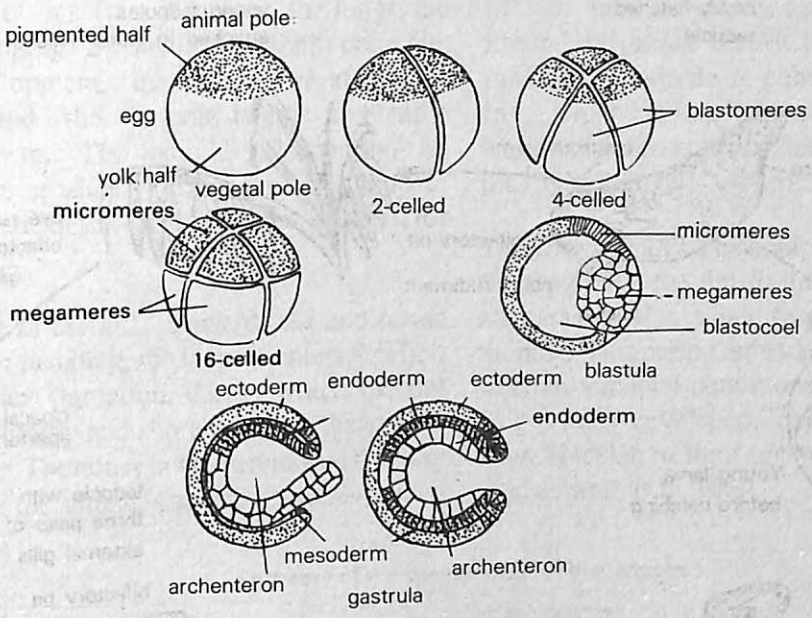


Fig. 4.9 Development of eggs upto three germinal layers

Formation of the tadpole: The zygote undergoes division and due to the division of cells a small solid ball of cells called the *morula* is formed. It has two types of cells, the smaller *micromeres* and the larger *megameres*. A small cavity appears inside the ball-shaped embryo called the *segmentation cavity*. The hollow embryo is known as the *blastula*. The micromeres divide faster than the megameres and, as a result of this, the segmentation cavity disappears. In its place a new cavity or *enteron* is formed.

The embryo becomes three-layered and because of this the embryo is called *triploblastic*. All the organs of the body develop from these germinal layers. The developing young one within the egg is now called an *embryo*. It receives nourishment from the yolk stored in the egg. At the end of a fortnight, the embryo hatches out of the egg, rupturing the egg membrane. The young one that comes out of the egg does not resemble its parents but it is able to lead an independent life. Such a self-supporting, immature young one, that does not resemble its parent is termed *larva*. The larva of a frog is known as a *tadpole*.

The first stage: The young tadpole has an oval head, a short trunk and a tail at its posterior end. It swims for some time and attaches itself to a water weed with the help of a *sucker* on the ventral side of its head. The eye and the eardrum are rudimentary.

The external gill stage: The tadpole soon develops a mouth and *cloacal aperture*. The mouth has horny jaws, eyes and three pairs of external gills. The tadpole breathes through its external gills. Each external gill is a highly branched, thin-walled filamentous outgrowth from the pharyngeal region. These are highly vascular structures and are the first set of respiratory organs.

Internal gill stage: The tadpole feeds on water weeds (herbivorous) and soon grows in size. The tail develops muscles and fins on its dorsal and ventral sides. The fins are different from those of fishes as they have no fin-rays. The external gills disappear and they are replaced by four pairs of *gill slits* which get covered by an *operculum* or *gill-cover*. The internal gills are the second set of

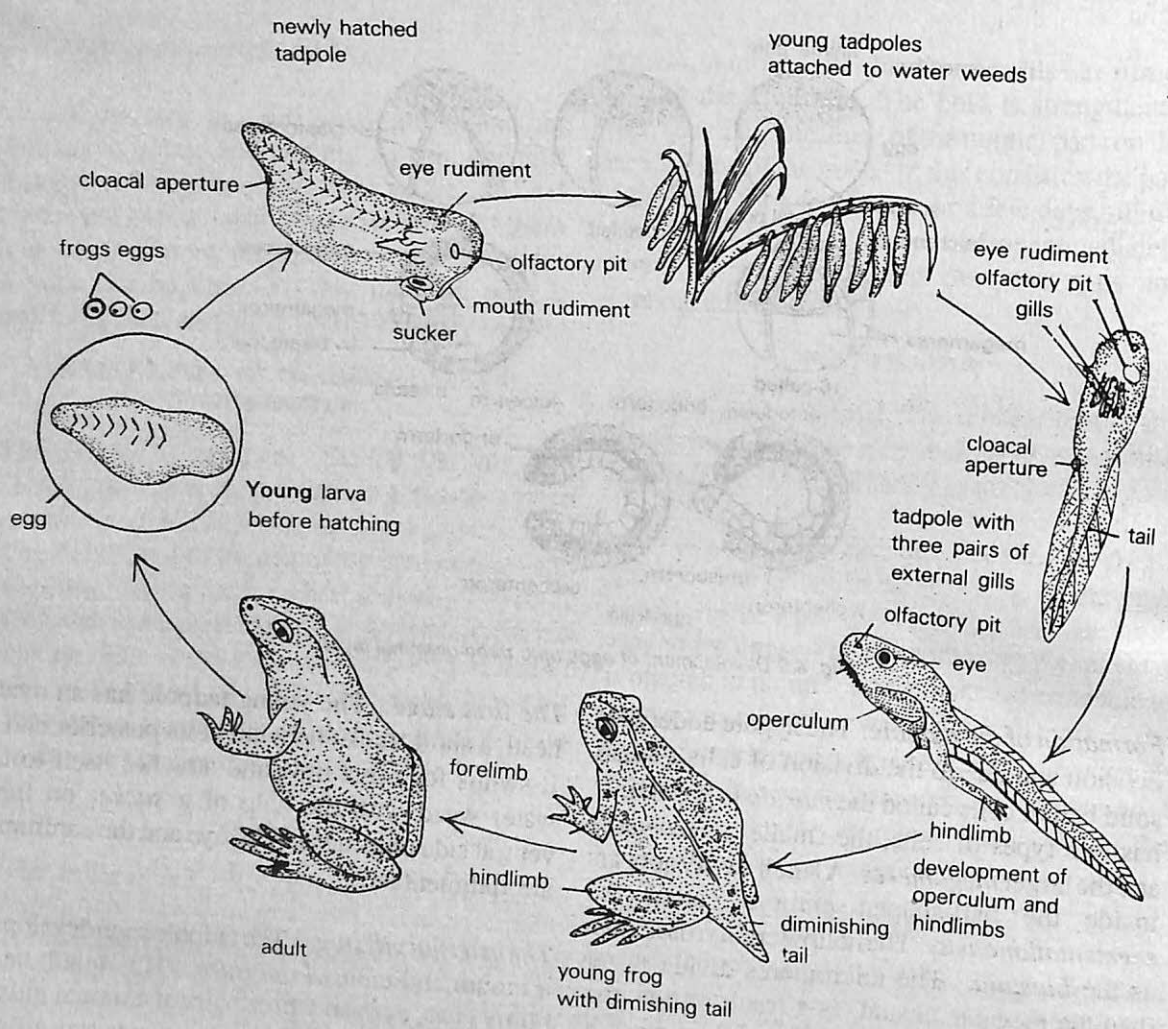


Fig. 4.10 The metamorphosis of frog

respiratory organs. The gill slits open into a cavity known as the *opercular chamber*. The opercular chamber opens to the exterior, through a small opening called the *spiracle*, on its left side. The tadpole resembles a fish at this stage, respires through gills, has lateral line sense organs and a tail-fin.

The respiratory current of water enters the pharynx through the mouth, passes through the gill slits into the opercular chamber, and finally goes out through the spiracle. The tail becomes more muscular and the tadpole moves about actively and feeds voraciously.

The development of hindlimbs: When the tadpole is about five weeks old, rudiments of the hindlimbs are visible at the base of the tail, on either side of the cloacal aperture. The tadpole is now carnivorous, chasing and ingesting small aquatic animals.

The development of forelimbs and lungs: The rudiments of the forelimbs also develop simultaneously, but are not visible as they are enclosed by the operculum. The rudiments of the limbs gradually develop and eventually give rise to the limbs. While the limbs are developing, a

third set of respiratory organs, the lungs, are also developing. By the time the limbs complete their development, the lungs are also well-formed and the tadpole begins to breathe through them. The internal gills continue to function but gradually disappear. The tadpole has two pairs of well-formed limbs and a tail for locomotion.

Shortening of the tail: Towards the end of ten weeks after hatching, the tadpole enters a period of dormancy starvation, during which the tail becomes stumpy and shorter, until it disappears completely. The horny jaws are replaced by bony jaws. Now the animal is able to lead a *terrestrial* life. Its mouth widens, teeth and tongue are formed and the alimentary canal becomes shorter. Finally the tadpole is converted into a young frog which is amphibious and carnivorous. Metamorphosis is stimulated by a hormone from the thyroid gland — thyroxine.

The young adult: The complete development of the frog from the fertilisation of the egg to the appearance of a small frog takes about three months. This period may vary slightly according to environmental conditions. The young, adult frog is fully developed, its skin changes colour from blackish to light green, and it can live on land as well as in water.

Summary of the development of the tadpole

Stage	*Duration*	*Special features*
1. Spawn		Convex surface of jelly acts as a lens to focus warmth of sun's rays on egg and so speeds the development. The sphere of jelly — prevents over-crowding, prevents ingesting by predators; gives buoyancy; protects the egg from infection. Small green algae may become trapped between the spheres; these give oxygen to the eggs and remove carbon dioxide.
2. The newly hatched tadpole	12-14 days after fertilisation	The swollen *belly* contains yolk. The sucker has mucous glands – for frequent attachment to water weeds. There is an incompletely developed eye, ear, nostril, unopened mouth.
3. Tadpole with external gills	about 20 days after fertilisation (1 week after hatching)	Mouth is opened and bordered by horny jaws. There are three pairs of branched, thin-walled external gills. Tail fins are explanded.
4. Tadpole with internal gills	2-3 weeks after hatching	Operculum is completely grown over the internal gills (4 pairs of internal gills) There is a long, coiled alimentary canal to digest vegetation. A spiracle appears.
5. Tadpole with hindlimbs	4-5 weeks after hatching	Mouth loses its grasping apparatus and 'normal jaws' are formed. The tadpole is carnivorous. Hindlimbs growing out with webbed digits.
6. Tadpole with fore and hindlimbs	7 weeks after hatching	Internal gills begin to be replaced by lungs. Forelimbs grow out through spiracle. Forelimbs actually tear their way out through operculum. Forelimbs are short with unwebbed digits. There are long powerful hindlimbs.
7. Tadpole just before final metamorphosis	10 weeks after hatching (3 months after fertilisation)	Presence of bony jaws, teeth, tongue, etc. Widening of the *lungs* takes place. Tail is being reduced by being 'eaten' from within by white corpuscles. Heart is three-chambered.

Activity 2: *Observe a model showing different phases of cleavage in the frog's egg.*

Activity 3: *Observe the prepared slides showing the blastula and gastrula (early and later stages).*

Activity 4: *Collect different stages of tadpoles in the external gill stage, operculum stage, hindlimb bud stage and hindlimb and forelimb stage. Put them in different bottles and preserve them. Label your specimen bottles; collect spawn in a separate bottle. How is it different from other eggs?*

Metamorphosis

In insects the newly hatched individual does not immediately resemble the adult. It slowly undergoes changes and develops organs of the adult. *This phenomenon of passing through different stages before becoming an adult is called metamorphosis.* (GK: *meta* — change; *morpho* — form). Metamorphosis can be of the of the following three types.

1. *Primitive or direct metamorphosis:* Here the newly hatched young ones resemble the adults in all aspects except colour and size, e.g., silver fish.

2. *Incomplete or gradual metamorphosis:* The newly hatched young ones differ from the adult not only in size and colour but also because of the absence of wings and reproductive organs. The other organs are similar to that of the adults. The young one in this immature stage is called a *nymph*. The nymph grows gradually in stages and undergoes moulting after each stage or *instar*. Its life cycle is completed in three stages—egg, nymph and adult, e.g., grasshopper, dragonfly.

3. *Complete metamorphosis:* In this case the young ones are completely different from the adult both in structure and habits. The young one is called a *larva*. The larva may also be called a *caterpillar* or *maggot*. After leading an active life, the larva changes into an inactive form — the *pupa*. In this stage the larval organs are gradually changed into the organs of the adult. Here we see a life cycle with four stages, namely, *egg, larva, pupa* and *adult* or *imago*. This type of metamorphosis is seen in the housefly, mosquito, butterfly, moth, etc.

The life history of the white cabbage butterfly

The white *cabbage butterfly (Pieris brassicae)* is very commonly seen in summer and its eggs are easily reared, so that all stages in its life cycle can be carefully observed. The butterfly belongs to the phylum *arthropoda* and class *insecta*. The life cycle of the butterfly exhibits complete metamorphosis.

It life history comprises four stages: 1. egg 2. larva 3. pupa 4. imago or adult.

Egg: The butterfly lays eggs on the ventral side of the leaves. The eggs are laid in April or May, on plants such as cabbages. They are about 2 mm long, yellow, conical in shape, and have vertical and horizontal ridges upon the surface. They are laid in batches of twenty to one hundred. Under suitable temperatures the eggs hatch out. Usually they hatch after seven to ten days. Just before this a black dot can be seen at the narrower end of the egg. This is the head of the larva, or *caterpillar*, which bites its way through the egg shell by means of its mandibles.

Larva (the growing stage): The larva of the butterfly is called a *caterpillar*. The caterpillar starts feeding on a leaf. At this stage the tiny caterpillar has a black, shiny head and a yellow

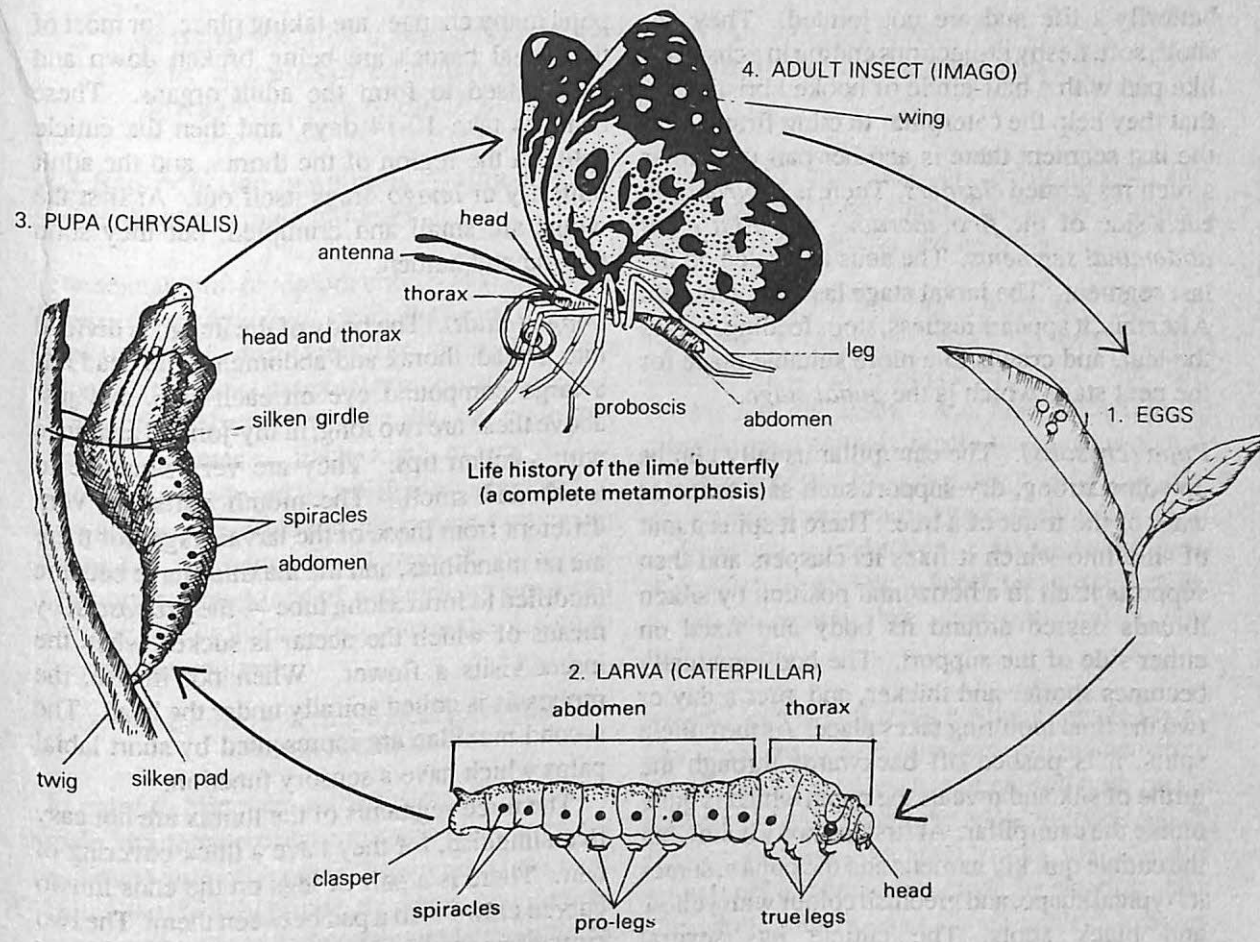


Fig. 4.11 The life history of white cabbage butterfly

body with a few white hairs. After a few days it stops feeding and begins to moult. This moulting is followed by a rapid increase in size, and four or five moultings take place before the caterpillar is fully grown. Throughout this time it continues to feed voraciously.

The body of the caterpillar is long, worm-like, segmented and covered with a thin cuticle. The body is divisible into the head, thorax and abdomen. The body consists of a head and thirteen segments. The head is spherical and does not have large compound eyes like the adult, but it has a ring of six small, black, simple eyes on each side toward the ventral surface, so that the caterpillar can see objects only if they are directly beneath its head, e.g., the leaf on which it is feeding. The head also bears a pair of short *antennae*. The mouth part consists of the *labium*, a pair of powerful *mandibles*, a pair of *maxillae* and a *labrum*. The *spinerets* (spinning glands) open near the base of the labrum and they produce a sticky secretion which is useful for making the pupal case during the pupa stage.

The thorax is three-segmented. Each segment bears a pair of legs. Each leg is thin, long and has five joints ending in a claw. These legs are called *true legs* or *thoracic legs*. These legs, besides being used for crawling, are also used to grip the leaf while the mandibles are biting through it. On the third, fourth, fifth and sixth of its ten abdominal segments there are pairs of *prolegs* or *false legs*. These are present only at this stage of the

butterfly's life and are not jointed. They are short, soft, fleshy projections ending in a cushion-like pad with a half-circle of hooked bristles, so that they help the caterpillar to cling firmly. On the last segment there is another pair of similar structures termed *claspers*. There is a *spiracle* on each side of the *first thoracic*, and *first eight abdominal segments*. The anus is located on the last segment. The larval stage lasts for a month. After this, it appears restless, stops feeding, leaves the leaf, and crawls to a more suitable place for the next stage which is the *pupal stage*.

Pupa (chysalis): The caterpillar usually climbs up some strong, dry support such as a fence or wall, or the trunk of a tree. There it spins a mat of silk, into which it fixes its claspers and then supports itself in a horizontal position by silken threads passed around its body and fixed on either side of the support. The body gradually becomes shorter and thicker, and after a day or two the final moulting takes place. As the cuticle splits, it is pushed off backwards through the girdle of silk and reveals the pupa, which is quite unlike the caterpillar. At first the body is soft, but the cuticle quickly hardens and the pupa assumes its typical shape, and greenish colour with yellow and black spots. The cuticle has several projections; the most prominent of these is on the dorsal surface. There are two lateral ones just below it. The girdle of silk passes between these so that the pupa cannot fall out of it. The pupa does not feed, and remains still except for occasional twitching of the abdomen. Inside the pupa many changes are taking place, for most of the larval tissues are being broken down and reorganised to form the adult organs. These changes take 10-14 days, and then the cuticle splits in the region of the thorax, and the adult butterfly or *imago* drags itself out. At first the wings are small and crumpled, but they soon expand and harden.

Imago (adult): The body of the imago is divided into a head, thorax and abdomen. The head has a large compound eye on each side, and just above these are two long, many-jointed antennae with swollen tips. They are very sensitive to touch and smell. The mouth parts are very different from those of the larval stage, for there are no mandibles, and the maxillae have become modified to form a long tube — the *proboscis*, by means of which the nectar is sucked when the insect visits a flower. When not in use, the proboscis is coiled spirally under the head. The second maxillae are represented by short labial palps which have a sensory function.

The three segments of the thorax are not easy to distinguish, for they have a thick covering of hair. There is a pair of legs on the ends in two curved claws with a pad between them. The two pairs of wings are joined to the dorsal surface of the second and third segments. They are covered with a powdery substance, which, when examined under a microscope, is seen to consist of scales of varying shapes. The scales cover the whole wing surface and overlap one another like tiles on a roof.

Activity 5: *Collect the larvae of the butterfly and observe their structure, mode of life, locomotion, etc.*

Activity 6: *Try to get some pupae of the butterfly. How is it different from a cocoon of a silk-worm. Keep it inside a match box with tiny perforations. Watch every now and then to see the emergence of a butterfly.*

Activity 7: *Catch a butterfly and observe its proboscis, wings, legs, etc. Why is it classified under lepidoptera? Display the above mentioned parts on a piece of black paper.*

4.3 Reproduction in animals — Union of male and female gametes

The sexual form of reproduction is also known as *gametic reproduction.* It is the usual method practised by multicellular animals. The reproductive units in sexual reproduction are two kinds of highly specialised cells, the male and female gametes. Each kind of gamete is commonly produced by a different parent and so two parents, one male and one female, participate in sexual reproduction. However, in certain flatworms, both kinds of gametes are produced by the same individual (such animals are said to be hermophrodites).

COURTSHIP AND FERTILISATION PATTERNS IN HIGHER ANIMALS

In order to bring about the fusion of gametes, a male and female organism must come together and mate with each other. Mating is a pattern of behaviour which brings the male and female organisms close to each other and in the process mature sperms produced by the male can fertilise mature eggs produced by the female. Fertilisation may take place inside or outside the body of the female. If it occurs inside body it is called *internal fertilisation* and if it occurs outside the body it is known as *external fertilisation.* For fertilisation to be effected the male has to court the female and lure into its territory. Courtship habits and methods of reproducing vary tremendously throughout the animal kingdom, and even between related animals.

Fish: Most fishes migrate to suitable grounds for breeding. Fishes use various devices to attract each other — differences in colour and size, production of sound and the discharge of stimulating chemicals into the water. Most female fishes reproduce by laying eggs and these eggs are fertilised externally by the male fishes.

In sexual reproduction, a male gamete fuses with a female gamete to form a single cell called a zygote which then develops into a new individual.

Amphibians: Adult frogs lay their eggs in water. The male frog can easily be distinguished from the female by the presence of *nuptial pads* on the first digit of each forelimb and its vocal sac which is associated with its mating 'song'. In spring, the male frogs in ponds start croaking (mating call). This attracts the females. The female cannot lay the eggs by herself. The male helps her by mounting on her back, holding her forelimbs and squeezing her sides with his forelimbs. Together they force out some of the eggs. Each time the eggs are laid, the male sends a cloud of sperm over them. The sperms fertilise the eggs. Thus fertilisation is *external* in spite of their oviparous nature.

Activity 8: *Prepare a bulletin-board display or flannel-board display showing reproduction in frog and fowl. How do they differ?*

In the animal kingdom it is usualy the male that plays the important role. Many male birds are more brightly coloured as compared to the female to the species or acquire a specially bright colour during the mating season. The males dance, puff themselves up, wriggle their tails or sing sweetly during the mating season. Fertilisation is usually internal. The egg is formed inside the body of the female and is hatched outside.

Mammals: Mammals are considered to be the most highly developed groups of animals, and they show a very specialised method of reproduction. They are viviparous, i.e., they give birth to their young alive. Fertilisation takes place within the body of the female and there is a long gestation period (varying according to each

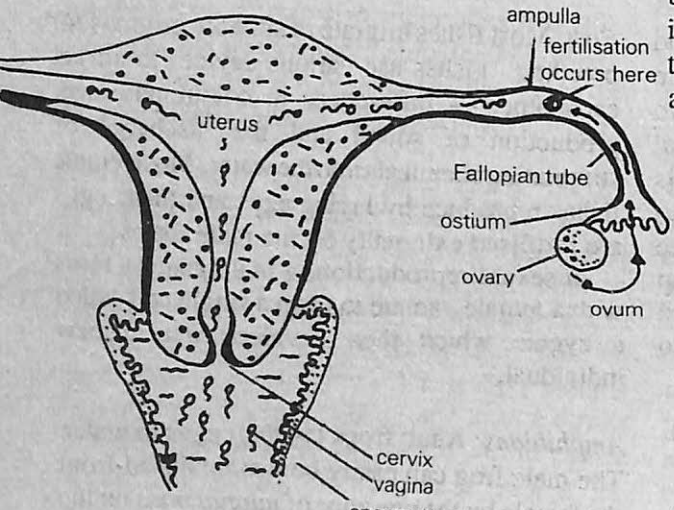


Fig. 4.12 Fertilisation of ovum

animal and species) during which the fertilised egg develops within the mother's body. It is nourished by her bloodstream.

BREEDING SEASON

The breeding season may be defined as that part of the year when an animal reproduces. The time of the breeding season is adjusted to the needs of a given species so as to afford the best chance for the survival of the offspring.

Before an animal can breed, it must grow to maturity. The mouse reaches maturity at about seven weeks whereas the elephant may not breed until the age of 15 years. In human beings, once the proper age is reached, breeding can take place throughout the year. Such type of animals are known as *continuous breeders*. Some animals may breed during a restricted period of the year and they are called *seasonal breeders*.

4.4 Other methods of reproduction

GEMMULATION OR ENDOGEOUS BUDDING

All fresh water and some marine sponges have a peculiar mode of asexual reproduction by internal buds called *gemmules*, which detach and develop into new individuals. These enable the sponges to tide over unfavourable conditions such as cold and drought.

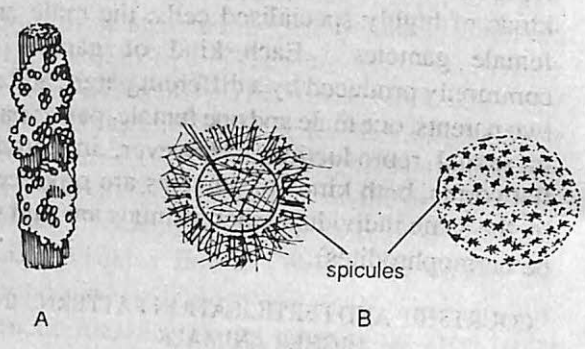


Fig. 4.13 A—Fragments of an old sponge (Carterius tubisperma) with gemmules attached to a dead twig.
B—Freshwater gemmule in external view.

REGENERATION

Regeneration may be defined as the ability of certain animals to replace or restore the lost or damaged parts of their bodies. It usually occurs naturally after an accident, but can be induced artificially by mutilation.

Amoeba undergoes binary fission and is said to be immortal since a parent gets distributed evenly into two offspring and the process continues indefinitely.

Regeneration in hydra: The power of regeneration in hydra was first reported in 1744 by Abraham Trembley. In an experiment, Trembley turned a hydra inside out by pushing a knotted thread through its pedal disc and drawing it out through

the mouth. He observed the migration of its cells from various regions.

Trembley found that if a living hydra is cut across into two, three or more pieces, each will grow the missing parts and become a complete hydra.

Regeneration may result in an increase in numbers but it is not reproduction because it is not a normal method of multiplication.

Activity 9: *Demonstrate the power of regeneration in hydra and planaria to your classmates using coloured plastic clay.*

Regeneration in planaria (Dugesia): Dugesia and other fresh water planarians exhibit remarkable powers of regeneration. If a worm is

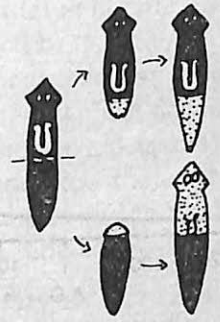


Fig. 4.14 Regeneration of Planaria (Dugesia)

cut transversely into two halves, the anterior half regenerates a new tail, while the posterior half develops a new head. A section from the middle of the body will regenerate both a head anteriorly and a tail posteriorly. The regeneration piece always retains the *polarity* of the whole animal and hence a head grows out from its anterior region, while a tail grows from its posterior region only.

If the anterior region is cut longitudinally into many parts, then each part grows a complete head, resulting in a several headed monster with a common tail. This rare phenomenon is known as *heteromorphosis*.

Regeneration in earthworms: If an earthworm is cut into two, the anterior half will regenerate a tail, but the posterior half cannot form a head, if

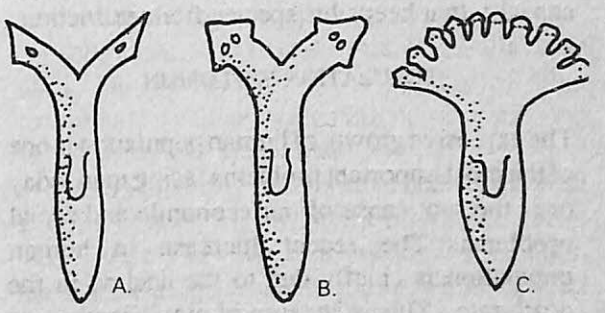


Fig. 4.15 Hetermorphosis in Planaria
A—Head split into two halves
B—Each half regenraes the missing parts.
C—Several-headed monster produced by repeated splits.

14 or more segments (14-17 segments — region of clitellum) are cut off. However, a head may be regenerated if only 4 or 6 segments are cut off at the anterior end. Sometimes the posterior half may regenerate a tail instead of a head. Such a double-tailed worm cannot feed and starves to death.

Regeneration in starfish (sea star): Sea stars have considerable powers of regeneration. A disc, deprived of all its arms, will regenerate them all quite readily. A single arm with a portion of a disc will regenerate an entire animal. But the process is very slow and may take as long as a year.

(Certain fishes and house lizards also show the power of regeneration. In human and other mammals, the wound healing process is an example for regeneration).

Activity 10: *Select any two invertebrates and vertebrates (not discussed in this unit). Write an autobiography of each animal with special reference to regeneration.*

4.5 Perpetuation of the human species — explosion — importance

The function of the reproductive system is to perpetuate the life of the species. Man has an efficient internal sexual system of reproduction which ensures continuance of the species though its individuals die. It is man's reproductive capacity that keeps his species from extinction.

POPULATION EXPLOSION

The explosive growth of human population is one of the most important problems facing man today or is the root cause of our economic and social problems. The recent increase in human population is chiefly due to the decline in the death rate. This is because of man's increasing control over disease-causing organisms, and improved sanitation and public health programmes started by the Government to eradicate epidemic and communicable diseases. It is also due to better control over natural calamities such as floods and famines.

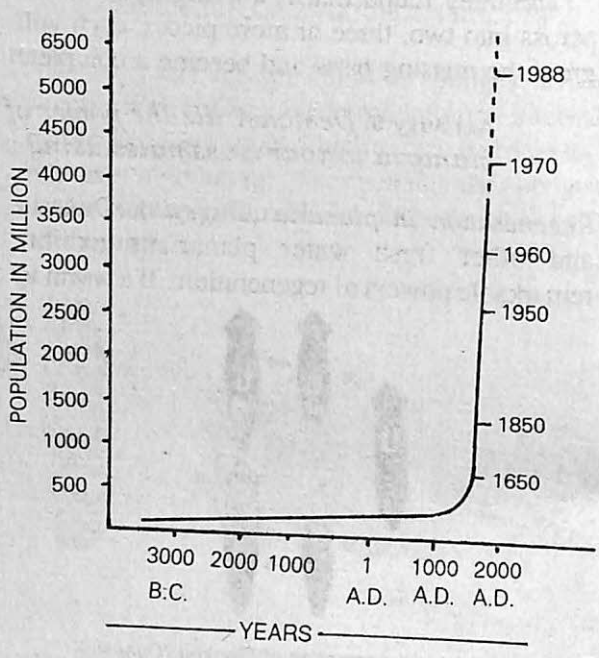


Fig. 4.16 Graph showing the rise in human population

Activity 11: *Get into small groups. Prepare one person from your group to give a microlecture on the 'rise in human population'. Use suitable cartoons on posters to illustrate the points you bring out.*

Some of the reasons why the size of the human families should be limited are:

1. A high rate of pregnancies is dangerous to the health of the mother.
2. The increase is agricultural production is not substantial and proportionate to the increase in population. Consequently, by and large in India, people remain under-fed and ill-fed. These children are more susceptible to diseases. Mothers are not able to supply the sufficient nutrients to the foetus. Hence they produce mentally and physically retarded children who are permanent burdens on the family and eventually a burden on society. India has about two crore physically and mentally retarded individuals. An equal number are unemployed. Under-employment is the fate of many more. Therefore, the prosperity of the nation lies in checking and stopping the increase in population. An understanding of the human reproductive system is an essential step towards controlling the population growth.

Activity 12: *See a film on population growth in the developing countries. Prepare a questionnaire on this and distribute it to your classmates. Collate the answers and conduct a class discussion on your findings.*

HUMAN REPRODUCTIVE SYSTEM

Human reproduction has some characteristics which are not found in other species. Some of them are:

1. There is no specific breeding season.
2. In females, the reproductive phase is accompanied by a regular and repeated menstrual cycle of 28 days.
3. The reproductive age is prolonged and therefore a female can produce 20 or more children during her life time.
4. Reproductive maturity is accompanied by the appearance of secondary sexual characteristics. The development of beard, hair on the body, deep masculine voice, etc. are some of the secondary sexual characteristics of the male. Similarly, the feminine characteristics, development of breasts, etc. are the secondary sexual characteristics of the female.

THE MENSTRUAL CYCLE

The birth rate can be checked by preventing pregnancy or fertilisation. As you know, fertilisation requires the fusion of the ovum and a sperm cell. The ovum is available for about two days of the menstrual cycle.

Today computerised devices are available to show the fertility period. A number of other techniques such as vaccination, physical and surgical devices are available.

Family planning centres have been opened all over the country to help people plan their family. The period between two successive children should not be less than three years. This helps full recovery of the health of the mother and proper care of the infant.

Activity 13: *Note down the slogans and advertisements about family planning that you see on the posters of buses and public places.*

THE REASONS FOR THE SLOW ADOPTION OF FAMILY PLANNING

1. *Mortality rate:* Mortality or death rate among children of the poor families is still very high in India. These families tend to have more children in the hope that at least a few will survive.
2. *Economic reasons:* Children are forced to work to earn money in some families. Therefore, parents feel that a large number of children is a must for increasing the family income.
3. *Traditional belief:* Most ignorant people believe that children are God's gifts. Many consider that preventing a pregnancy is a sin.
4. *Other reasons:* Absence of any source of entertainment makes sex the only source of entertainment.

   They are also ignorant about the mechanism of the human reproductive cycle.

Population education: The knowledge about the relation of population size or growth and the availability of resources for the welfare of the society is called *population education.*

Activity 14: *Prepare posters on mortality, health of the mother, frequent pregnancies, food shortage and unemployment. Write suitable captions to bring out the main points.*

The prosperity of a nation is connected with the prosperity of her individuals. Knowledge about population and its welfare gives us a responsibility to educate the persons who are and who will be affected by over-population in the country. Only by drastically controlling the rate of population growth can we ensure better food, medical facilities, hygiene and housing for the masses of India.

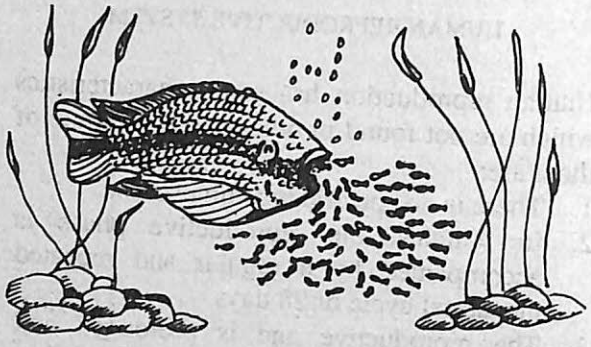


Fig. 4.17 Mouth brooding in the Tilapia fish

4.6 Parental care — meaning and need — examples of parental care

The young ones of any species are so fragile and powerless that they are not able to compete with the adults of the same species and individuals of other species. Therefore, they have to be protected till they are able to live independently. You may have seen birds feeding and protecting their offspring. This nurturing of the infant upto a certain age is known as *parental care*. The period of *parental care* varies according to species and is more prevalent in higher animals.

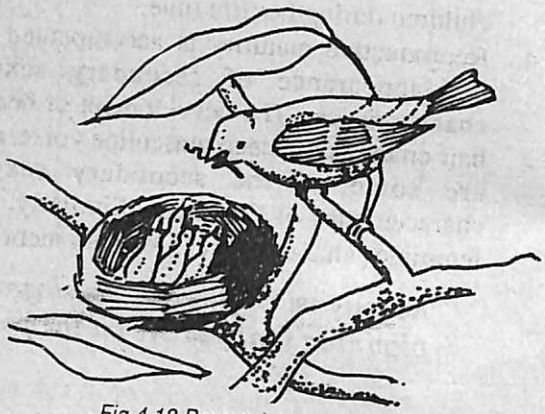


Fig.4.18 Parental care in birds

Activity 14: *Collect pictures of animals showing different modes of parental care. Paste them in your nature album.*

Many invertebrates, fishes and amphibians spawn a large number of eggs. Such prolific egg laying is characteristic of any species living in water and those in which parental care is not well-developed. In certain species of sharks, the yolk sac of each embryo attaches itself to the uterine wall of the mother through which the young obtains nourishment. In certain fishes (tropoda) the uterine epithelium secretes a milky substances to feed the young ones.

In the Surinam toad, eggs are carried in a pouch on the back of the females. The male midwife toad *(Alytes obstetricans)* wraps strings of fertilised eggs around its legs and carries them on its body until they hatch. In the European mountain salamander, the larvae develop in the

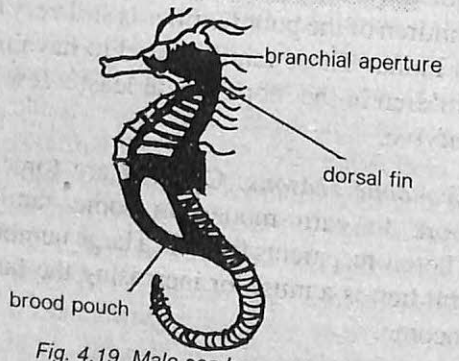


Fig. 4.19 Male sea horse with brood pouch

uterus of the mother. In the male sea horse (hippocampus) an abdominal pouch is developed. Fertilised eggs are placed in the pouch and the male incubates the eggs. A few snakes like the python coil around the eggs until they are hatched.

Fig. 4.20 Parent bird building a nest

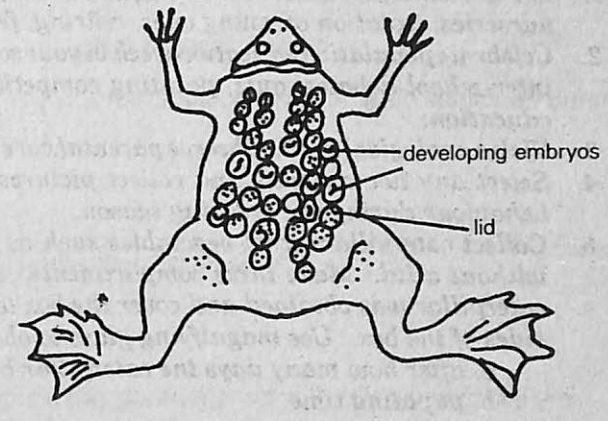


Fig. 4.21 Female Surinam toad

Parental care is developed to a greater degree in birds and mammals. Hence the young ones are taken care of by the parents for several months or even years after birth.

There are isolated instances of parental care among fishes and amphibians but the phenomenon is seen at its best in reptiles, birds and mammals.

Parental care includes looking after the eggs before hatching, protecting and guarding the young ones from predators, continuously hunting for food for them and teaching them how to survive best in existing surroundings.

Some basic concepts

1. Coelenterates exhibit two different morphological types of individuals, the polyp and the medusa.
2. Metamorphosis is a phenomenon of passing through different stages before becoming an adult.
3. The reproductive units in sexual reproduction are two kinds of specialised cells known as *gametes*.
4. Regeneration is the ability of some animals to restore the lost parts of their bodies.
5. The chief function of the reproductive system is to perpetuate the life of the species.
6. Planned families help the country to control over-population.

Some suggested projects / activities

1. *Try to visit a pisciculture or an aquaculture farm. Observe the different kinds of fish, their nurseries, isolation of young ones, rearing, feeding and artificial breeding.*
2. *Celebrate population education week in your school. Conduct oratorical and essay competitions inter-school debates, quiz, painting competitions, etc. with special reference to population education.*
3. *Visit a zoological park. Observe parental care in different animals. Record your observations.*
4. *Select any two animals and collect pictures or draw diagrams regarding their courtship behaviour during the breeding season.*
6. *Collect caterpillars from vegetables such as brinjal and cabbage. Take an empty shoe box without a lid. Make three compartments. Put in pieces of the vegetables from which the caterpillar was obtained and cover the box with glass paper. Make tiny perforations on the sides of the box. Use magnifying glass to observe the following:*
   a. after how many days the caterpillar becomes inactive.
   b. pupating time.
   e. time taken by pupae to hatch.

REVISION

I. Questions

1. What is alternation of generation? Illustrate this phenomenon in hydra.
2. What is reproduction?
3. What are male and female gametes?
4. What is the significance of sexual reproduction?
5. Define gemmulation and regeneration.
6. What is the present population of India and the world?
7. Give reasons for the high rate of mortality among children in India.
8. What is population education?

II. Differentiate between:

1. blastula and gastrula. 2. male and female gametes. 3. parental care and breeding.

III. Fill the blanks.

1. The butterfly belongs to the phylum ..... .
2. The caterpillar is the .....

3. The caterpillar has ..... of true legs and ..... of prolegs.

4. Frogs belong to the class ..... .

5. The tadpole has ..... pairs of external gills.

6. The male frog has ..... for croaking and it is well developed during the breeding season.

IV. Write short notes on

a. caterpillar. b. tadpole. c. external fertilisation. d. imago.

V. Answer the following questions:

1. Define the term metamorphosis. Explain this phenomenon with reference to the life history of frog. Illustrate your answer.

2. Describe the life history of the butterfly with the help of diagrams.

3. Give an account of parental care in animals.

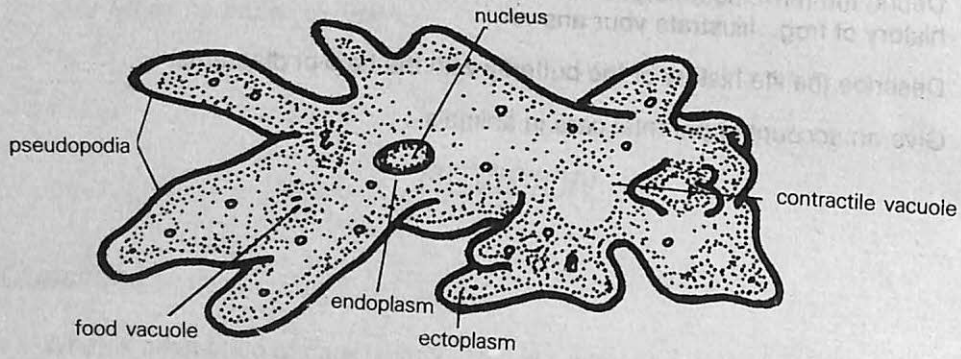
PRATICALS

I

Examine the following microslides and identify the parts described below:

(i) Amoeba

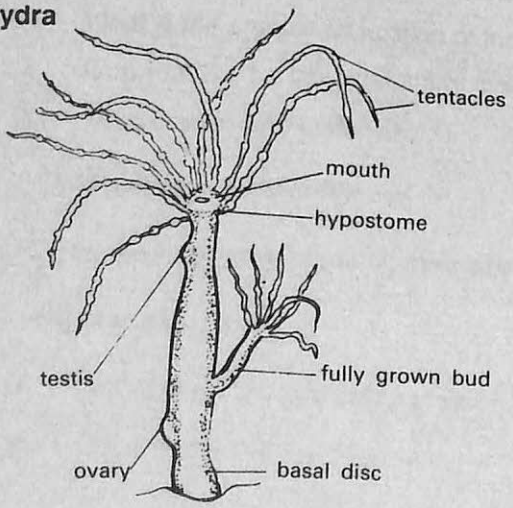
Sub-kingdom: Invertebrata
Phylum: Protozoa



Amoeba proteus

The amoeba is aquatic. It is irregular and has small outgrowths in its body called *pseudopodia*. These are the locomotor organs. The protoplasm is differentiated into an outer *ectoplasm* and an inner *endoplasm*. The nucleus, food vacuoles, contractile vacuoles, etc. are present.

(ii) Hydra



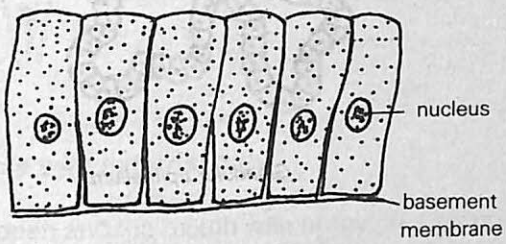
Hydra

Sub-kingdom : Invertebrata
Phylum: Coelenterata

The Hydra is a fresh water animal. The common species is about a quarter to half inch long. It possesses about 6-10 *tentacles*, surrounding an elevation, the *hypostome*, in which the *mouth* is located. The hydra is highly contractile, containing cells which function as combined sensory and muscular elements. The stinging cells contain *nematocysts* capable of extruding a barbed thread that occurs in the ectoderm.

(iii) Epithelial tissues

(a) *Columnar epithelium*

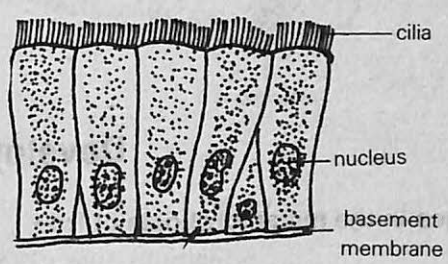


Columnar epithelium

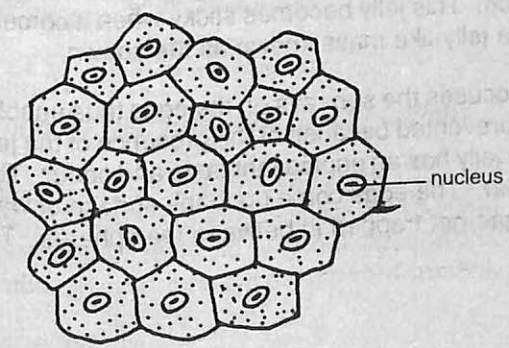
The cells are tall and pillar-like. They rest on a thin membrane called the *basement membrane.* The cells are broad at the outer end and narrow at the inner end. Each cell has a prominent nucleus. Normally the cells lie close to each other without any intercellular spaces. Since the cells resemble *columns* or *pillars,* they are known as columnar epithelial cells. The columnar epithelium lines the inner surface of the stomach, intestine, ducts of glands, etc.

(b) *Ciliated epithelium*

These cells are tall and cylindrical in shape and rest on a thin membrane, the *basement membrane.* The free end of each cell has a number of minute, hair-like, protoplasmic projections known as *cilia.* They are capable of locomotion. Because of the presence of cilia, these cells are known as ciliated epithelial cells. These cells line the nasal chambers, trachea, bronchi, spinal cord and the urinary bladder.



Ciliated epithelium



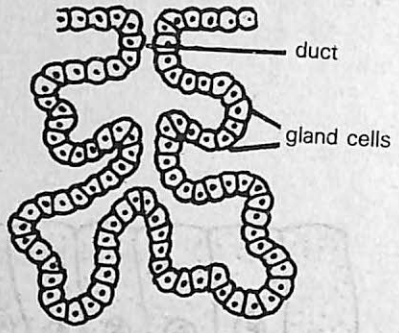
Squamous epithelium

(c) *Squamous epithelium*

The squamous epithelial cells are flat and disc-like. They are arranged like the tiles on a mosaic floor. The cells are inter-connected by protoplasmic bridges. There are two types of squamous epithelium, namely, *simple squamous epithelium* and *stratified squamous epithelium.* The simple squamous epithelium consists of a single layer of cells (e.g., lining of blood vessels). The stratified squamous epithelium is formed of several layers. It is also known as *pavement epithelium.* It is found lining the buccal cavity and the skin of vertebrates. It is protective in function.

(d) *Glandular epithelium*

It is a kind of epithelial tissue made up of glandular cells. The cells are of different sizes and may be cubical, hexagonal or polygonal in shape. The cytoplasm is granular. These cells are secretory in function. The glandular cells which are single are known as *goblet cells.* They are found in the mucous membrane of the intestine, where they secrete a sticky substance known as *mucus.* Glandular epithelium is also found in the different glands of the body such as the salivary glands, liver and pancreas.



Glandular epithelium

II

Developmental stages

Stages in the metamorphosis of frog

Examine the development stages of the following:

(i) *Spawn*

The eggs are coated with a layer of jelly-like substance. This jelly becomes sticky when it comes in contact with water and the eggs remain together as a jelly-like mass known as the *spawn.*

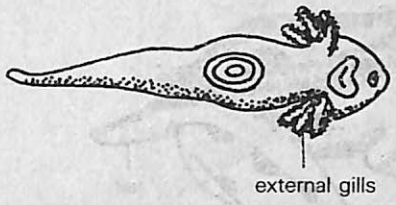
The convex surface of the jelly acts as a lens and focuses the sun rays on the eggs thus enabling them to develop faster. Overcrowding of the eggs is prevented because of the presence of the jelly. The jelly acts as a layer of protection to the eggs. The jelly has an unpleasant taste and odour. Thus it keeps away any predators. It has a tendency to float. The eggs come up to the surface of water and thus get sunlight and warmth and air. Some algae get trapped in between the spheres. This provides oxygen to the eggs.

(ii) *Newly-hatched tadpole* (or) *tadpole on weeds*

The embryos break free from the jelly as incompletely developed larvae. They are known as *tadpoles.* Eyes, ears, and nostrils are incompletely developed. An unopened mouth is present. The tadpole depends on the yolk contained in the body to sustain itself. It has some suckers with mucus glands which help the tadpoles to attach themselves to the jelly or water weeds. The swollen belly contains

Tadpole on weeds

a storehouse of yolk which was earlier absorbed from the remains of the egg.



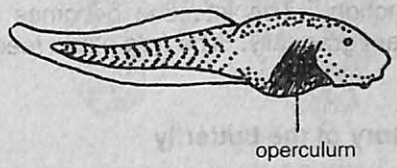
Tadpole with external gills

(iii) *Tadpole with external gills*

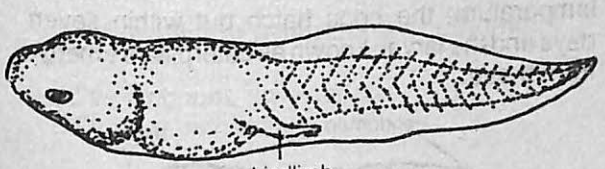
The eyes open and the mouth with horny jaws helps the tadpole to rasp algae from stones. There are three pairs of *external gills.* These external gills are branched and thin-walled. The suckers are present for attachment to stones, feeding and resting. Expanded tail fins are present.

(iv) *Tadpole with internal gills (Operculum stage)*

The external gills degenerate and three pairs of *internal gills* develop in their place. These gills are connected to gill pouches. The *operculum* is a fold of skin which begins to grow backwards over the external gills. The limbs, too, start to develop. This stage reveals the piscine ancestry of the frog and is of great evolutionary importance.



Tadpole with internal gills



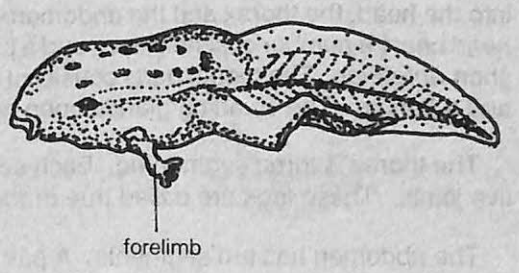
Tadpole with hindlimbs

(v) *Tadpole with hindlimbs*

The mouth loses its rasping apparatus and develops normal jaws. At this stage the tadpole is carnivorous, chasing and ingesting small aquatic animals. A spiracle develops. The hindlimbs begin to grow out with five webbed digits.

(vi) *Tadpole with forelimbs and hindlimbs*

The internal gills are replaced by lungs. The left forelimbs grow out through the spiracle. The right forelimb actually tears its way out through the operculum. Powerful, long hindlimbs are present.

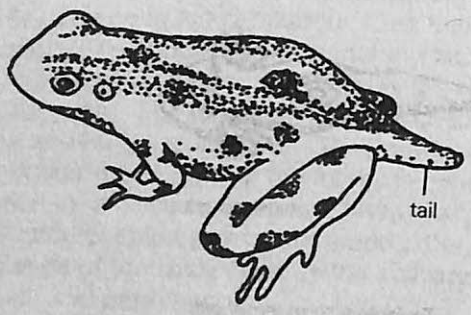


Tadpole with forelimbs and hindlimbs

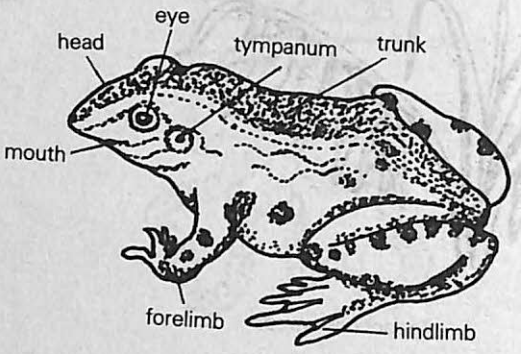
(vii) *A tailed frog*

The sucker and the mucus glands degenerate. The lungs arise from the pharynx. The tadpole comes to the water surface at this stage to gulp

air. The internal gills begin to degenerate. The tail fin is small and the *tail becomes short*. The eyes are prominent.



A tailed frog



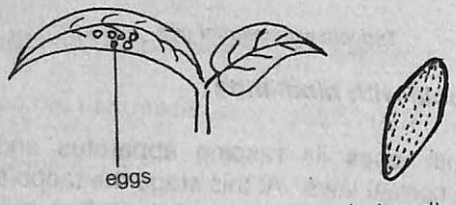
Adult frog

(viii) *A fully formed adult frog*

The horny jaws disappear. The tadpole starts feeding with the help of the mouth with true jaws. The lungs become large to suit a terrestrial mode of life. The legs become longer to aid the terrestrial mode of locomotion. The intestine becomes shortened and the stomach becomes wide. The tail disappears gradually. The frog starts feeding on insects.

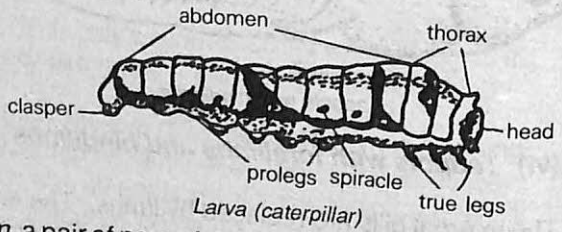
Life history of the butterfly

(i) *Egg*



The female butterfly lays eggs on the ventral side of leaves. These are attached to the surface of the leaves by sticky secretions. Under suitable temperature, the eggs hatch out within seven days and the larvae known as caterpillars emerge from these.

(ii) *Caterpillar*



Larva (caterpillar)

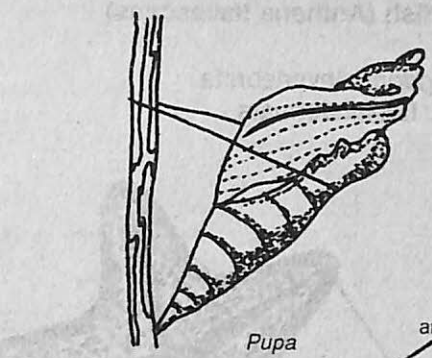
The larva of the butterfly is known as the *caterpillar*. It is worm-like and its long body is segmented and covered with a soft cuticle. The body is divisible into the head, the thorax and the abdomen. The head bears a number of simple eyes and a pair of short *antennae*. The mouth parts consist of a *labrum*, a pair of powerful mandibles, a pair of maxillae and a labium. The spinning glands open near the labrum and they produce a sticky secretion.

The thorax is three segmented. Each segment bears a pair of legs. Each leg in this section has five joints. These legs are called true or *thoracic legs*.

The abdomen has ten segments. A pair of *false legs* or *prolegs* are present in the 3rd, 4th, 5th, and 6th abdominal segments. The 10th segment also bears a pair of prolegs called *claspers*.

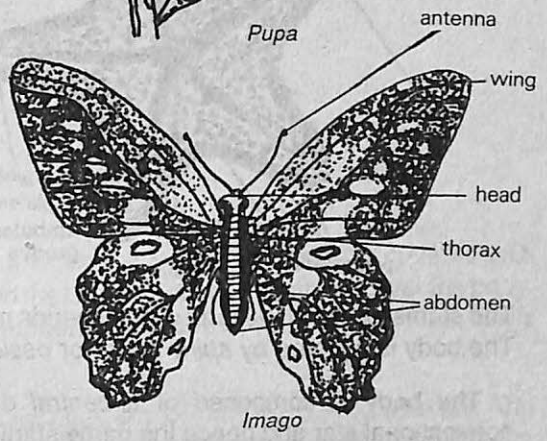
(iii) *Pupa* (Chrysalis)

When the larva is fully grown, it stops feeding. It then attaches itself to a leaf by the claspers and with the help of spinning glands it spins a pad of silk around itself. The pupal stage lasts for about 10–12 days. Inside the pupal case, the larval tissues are broken down and fresh tissues are built up.



(iv) *Adult butterfly* (Imago)

The adult butterfly*(imago)* takes its shape gradually inside the pupal case and at the end of the pupal period, the imago opens the pupal case and emerges.



Imago

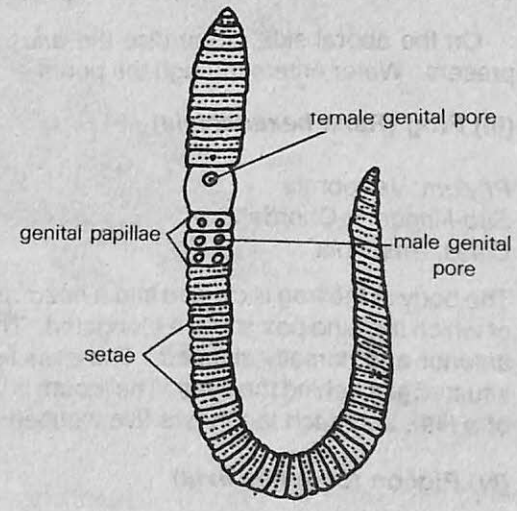
The body of the imago is divided into a *head, thorax* and *abdomen.* The head has a large *compound eye* at each side, and just above these are two long, many-jointed *antennae* with swollen tips. They are very sensitive to touch and smell. The mouth parts are very different from those of the larval stage. The *maxillae* have become modified to form a long tube, the *proboscis,* through which the nectar is sucked. The second maxilla are represented by short *labial palps* which have a sensory function. There are a pair of legs on the ventral surface of each thoracic segment. There are two pairs of *wings.*

Examine the following preserved specimens:

(i) Earthworm (Pheretima posthuma)

Sub-kingdom: Invertebrata
Phylum: Annelida

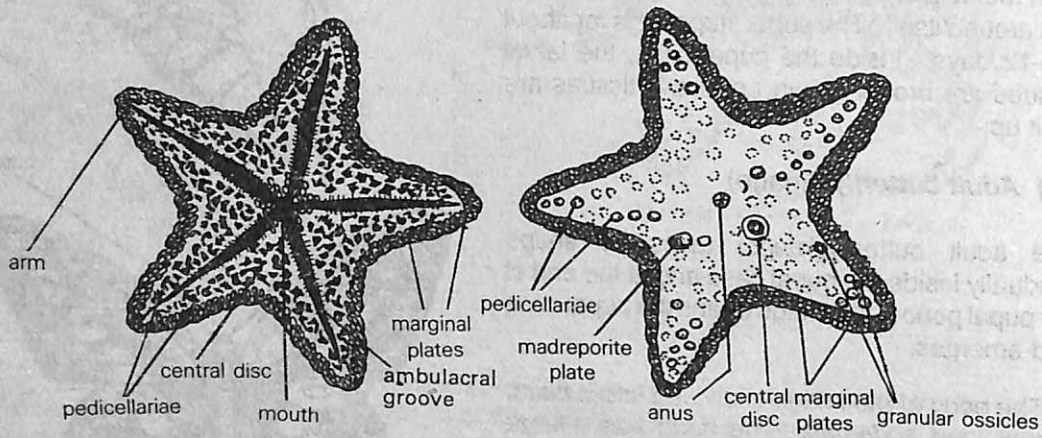
The *pheretima posthuma* (earthworm) is a burrowing worm which lives in moist soil or sand. The body is long, narrow, cylindrical and bilaterally symmetrical. The body of the earthworm is divisible into a number of similar rings known as segments or *metameres.* There is a fleshy lobe-like *peristomium* surrounding the anterior mouth opening. There is a thick girdle-like bank of glandular tissue, the *clitellum,* which surrounds the 14–16th segments. Each segment of the body except the first and last, bears minute rod-like chitinous *setae.*



Pheretima posthuma (Earthworm) ventral view

(ii) Starfish (Anthena flavescens)

Sub-kingdom : Invertebrata
Phylum: Echinodermata



The starfish is a marine form which spends most of its life crawling in shallow water of sandy shores. The body is covered by *spiny plates* or *ossicles*. Hence it is known as a spiny skinned animal.

The body is composed of a *central disc* and five radiating arms. These resemble the conventional star and hence the name starfish. The body can be divided into two regions, namely, the *oral* and the *aboral* regions. The oral region faces the substratum. It has a mouth in the centre of the disc from which radiates five grooves—one in the centre of each arm. These are known as the *ambulacral grooves*. slender cylindrical *tube feet* project through the ambulacral grooves. They are helpful in locomotion. Small pincer-like structures called pedicellaria are present in the region of the mouth. These are helpful in capturing the prey.

On the aboral side of the disc the *anus* and a calcarious plate known as the *madreporite* are present. Water enters through the pores of the madreporite into the vascular system of the animal.

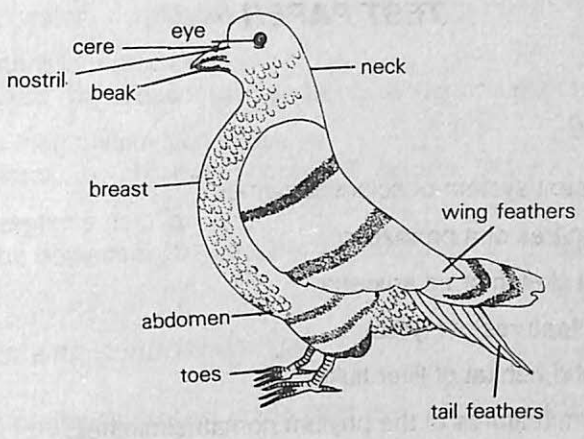
(iii) Frog *(Rana hexadactyla)*

Phylum: Vertebrata
Sub-kingdom: Chordata
Class: Amphibia

The body of the frog is divided into a *head* and *trunk*. There are two pairs of locomotor appendages, of which the hind pair is more elongated. The *skin* is smooth, moist and scaleless. The *nostrils* are anterior and dorsally situated. The *eyes* lie dorsally on the head. The *tympanic membranes* are situated just behind the eyes. The mouth is very broad. Each hand bears four fingers and a rudiment of a fifth, and each foot bears five webbed toes.

(iv) Pigeon *(columba livia)*

Sub-kingdom: Vertebrata
Phylum: Chordata
Class: Aves

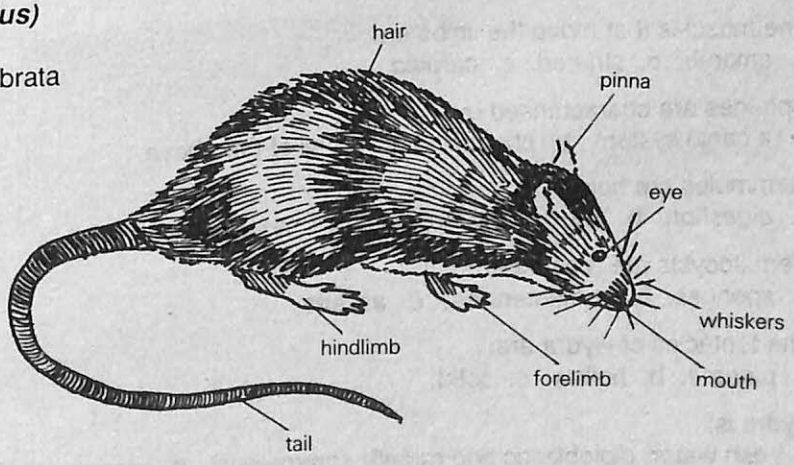


The pigeon is a common bird found in South India. It is warm-blooded. Its body is covered with feathers. The quill feathers are present in the wings and the tail. The contour feathers cover the body. The filoplumes are present in between the contour feathers. The down feathers cover the newly hatched young ones.

The body is divisible into a rounded head, a long mobile *neck, a short* trunk and a reduced *tail.* The eyes are provided with *eyelids* and *nictitating membranes.* The head is drawn out into a break in the front. The tongue is immobile. External nostrils are present at the base of the beak. A patch of swollen skin, the *cere,* is seen over the nostrils.

(v) Rat *(Rattus rattus)*

Sub kingdom: Vertebrata
Phylum: Chordata
Class: Mammalia



Rat

The body of the rat is divisible into the *head,* the *trunk* and the *tail.* The eyes are protected by well-developed *eyelids.* There is a pair of external nostrils at the tip of the snout. The external ear lobes or pinnae are characteristic of all mammals. The tip of the snout has a number of chin–whiskers or *vibrissae.* The body is covered with hair. The tail has a number of ring-like constrictions. The fore- and hindlimbs are well-developed.

TEST PAPER I

I. *Answer the following:*

1. Who started the present system of scientific names?
2. Name the salient features of a protozoan.
3. Draw a neat labelled sketch of an amoeba.
4. Explain the external features of Hydra.
5. Describe the habit and habitat of liver fluke.
6. Enumerate the salient features of the phylum nemathelminthes.
7. In what way do annelids differ from nemathelminthes?
8. Explain the general characteristics of arthropods.

II. *Choose the best answer for each of the following:*

1. A group of cells are known as
   a. systems. b. tissues. c. organs.
2. A group of tissues are known as
   a. cells. b. organs. c. systems.
3. Organs work together as
   a. tissues. b. cells. c. organ systems.
4. The muscles that move the limbs are
   a. smooth. b. striated. c. cardiac.
5. Sponges are characterised by
   a. a canal system. b. choanocytes. c. all of the above.
6. Gemmules are helpful in
   a. digestion. b. asexual reproduction. c. sexual reproduction.
7. Nematocysts are present in:
   a. sponges. b. coelenterates. c. ascaris.
8. The tentacles of Hydra are:
   a. pinnate. b. hollow. c. solid.
9. Hydra is:
   a. fresh water, diploblastic and radially symmetrical. b. marine, diploblastic and radially symmetrical. c. fresh water, triploblastic and radially symmetrical.
10. Earthworms respire through
    a. moist skin. b. clitellum. c. ctenidia.

11. Tissue fluid is also named
    a. lymph. b. water. c. plasma.

12 Mammary glands are modified
    a. sweat glands. b. sebaceous glands. c. endocrine glands.

13. The colour of mammalian skin is due to
    a. melanophores. b. chromatophores. c. keratin.

14. Sebacious secretions help in
    a. keeping the body cool. b. keeping the body hot. c. keeping the body oily and protected.

III. Fill in the blanks with suitable words.

1. The two sets of glands present in the skin are ..... and ..... .

2. ..... is converted into vitamin D by sunlight.

3. All birds and mammals maintain a constant body temperature and hence they are called ..... .

4. ..... glands which produce wax are present in the ear.

5. Liver fluke causes a disease known as ..... .

6. In platyhelminthes, excretion is carried out by ..... cells.

TEST PAPER II

I. Answer the following questions:

1. How do fish get their oxygen?
2. Explain the external morphology of the shark with suitable illustrations.
3. What are amphibians? How do they differ from other vertebrates?
4. Describe only the trunk region of the frog.
5. In what ways are reptiles better adapted to life on land than are amphibians?
6. List the different kinds of feathers seen on birds.
7. What are the main characteristics of mammals?
8. What does 'warm-blooded' mean?
9. What are poikilotherms?

II. Give scientific reasons for the following:

1. Leg muscles are heavier and more powerful than the other muscles.
2. The muscles of the forearm are known as biceps and triceps.
3. A sprain is more dangerous than a stress or strain.
4. We cannot accelerate our heart beats as we like.

III. Differentiate between the following:

a) tendons and ligaments. b) voluntary and involuntary muscles. c) biceps and triceps.

IV. Name the types of tissues found in

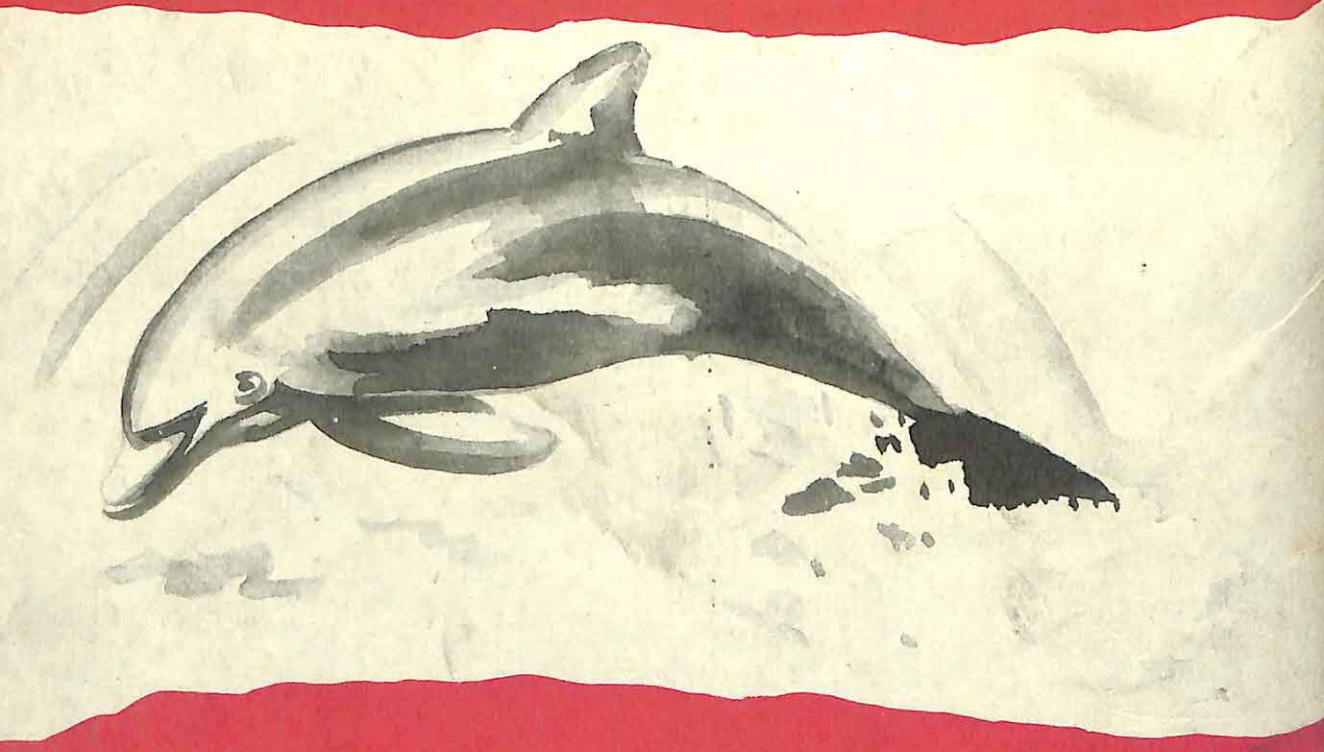
a) the stomach. b) the intestine. c) the skin.

V. Name the important muscles in the following:

Muscles of the arm	Muscles of the leg

VI. Write short notes on:

a. adulteration of food. b. blastula. c. gastrula. d. regeneration. e. parental care.



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